MANUAL
OF
PHOTOGRAPHY

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PREPARED UNDER THE SUPERVISION OF

BRIGADIER GENERAL A. W. GREELY,

CHIEF SIGNAL OFFICER,

FOR THE USE OF THE U. S. ARMY.

BY

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The Manual of Photography, prepared by direction of the Secretary of War for use in the Army of the United States, is approved, and will be published for the information and guidance of all concerned.

JOSEPH B. DOE,

Acting Secretary of War.

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PREFACE.

While the value of photography as an aid in the art of war has been recognized for a long time, its successful employment in military operations is of recent date; its introduction is largely due to the modern improvements in apparatus and methods which have rendered its operations practicable in the field. Its application requires special training for a number of men in the military establishment, and necessitates a brief manual. Experience with selected noncommissioned officers has shown that about one in ten can be made a good photographer, about four out of five will become fair operators, while about one in seven will fail to comprehend enough of the processes to render his services valuable to his military superiors. The experience of the writer, gained in the instruction of the noncommissioned officers of the Signal Corps at the school at Fort Riley, Kans., has led him in the preparation of this set of instructions to omit many of the details of the photographic methods laid down in the text-books, and it has been his object to explain in as simple, nontechnical language as possible such of the operations of photography as will prove of value for military purposes.

He has drawn largely on his experience in the field, in Central America and in the far west, for the selection of such processes and methods as are especially suitable for use in the field. Sufficient of the theory of the various processes has been given to enable the student to understand the why and how of the operations, and to serve as a guide to their practical application. Details have been avoided as much as possible, since

experience is the best teacher, and adaptability to surroundings is an absolute essential to success in military photography. Skill in manipulation comes only after considerable practice and experiment. In preparing the chapter on photographic topography, a knowledge of the elementary topographical methods has been presupposed. A chapter on balloon photography and topography has been omitted, as separate instructions will be prepared on this subject. The author acknowledges his indebtedness to Gen. A. W. Greely, Chief Signal Officer of the Army, for his assistance in suggesting the scope and limits of the work and for critical advice as it progressed, as well as to the valuable publications of the following authors: Abney, Burrows, Trail-Taylor, the various annuals of the Photographic Times, the International Annual, Wilson's Mosaics, and the current photographic periodicals.

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First Lieutenant, Signal Corps.

SAN ANTONIO, TEXAS,
January 1, 1896.

MANUAL OF PHOTOGRAPHY.

INTRODUCTORY CHAPTER.

Value of Photography. Adaptability to surroundings and resourcefulness in difficulties are two of the most essential qualifications for success in military photography, which is one of the most important aids for rapid acquirement of military information in the field. The compactness of modern apparatus and the rapidity of the recent photograph processes render the reproduction of terrene and enemies' works or positions the labor of a few hours, while formerly it necessitated days and weeks to achieve the same object. A military photograph possesses value from the fact that it contains an accurate and graphic description of the object desired, and can be made in much less space of time than by any of the processes of manual reproduction.

Requisites. Artistic effect is not essential, for the photograph is desired as a source of information, whose first requisite is absence from failure, as reexposure will not as a rule be possible. Technical rather than artistic skill is that which must be cultivated. It is impossible to give any general rule for field work, as circumstances are so varied that an operator must rely upon his judgment and ingenuity to overcome the many little inconveniences and mishaps which will constantly arise in the progress of his work.

Reconnoissance. When not pressed for time and with an abundance of transportation, photography in the field is as simple and convenient as working in a well-equipped dark room, but as a rule when field military photographs are desired they must be made rapidly with little apparatus and no conveniences. In

reconnoitering work the camera is especially valuable, as the entire country may be photographed in a few minutes and the finished prints can be ready by the time the descriptive report is written, thereby giving the commanding officer a much fuller and more detailed source of information than could be acquired by any of the present processes of field topography.

Field Equipment. The hand camera and roll holder are especially valuable in rapid reconnoissance work when used in conjunction with the bicycle, and results may be obtained more rapidly than by a mounted reconnoissance using the cavalry sketching board. For hasty work in the field, the photographer needs but little in the shape of impedimenta. A hand camera, preferably 5″ by 7″ with Russia leather bellows, double plate holders, or a roll holder, a rapid rectilineal lens, pneumatic shutter, folding tripod, and rubber focusing cloth, in which the camera may be inclosed for protection against the weather, will prove a compact and light kit for any field work. The cut films now manufactured possess a great advantage over glass, owing to their lightness, portability, and absence from liability to breakage.

Substitutes for Dark Room; Transportation. After the exposures have been made they may be developed in a dark tent, if this is at hand; if not, an excellent substitute can be constructed out of red and black cloth. The following is a description of one used by the author in Central America, and proved extremely efficient, very compact and portable: He made a dark room of cubical form, 5′ by 4′ by 3′ on the edges, of one thickness of black alpaca and one of turkey-red cotton sewed together, and one end being doubled so as to fold back like a curtain. The edges were served with rope, and eyes worked in the corners of the top so that it could be suspended in an ordinary wall tent. When not in use it folded up into a very small space. The negatives can be developed

at night in a room or tent. One of the many collapsible lanterns now on the market, or an ordinary camp lantern, with a couple of thicknesses of ruby cloth or envelope paper, will serve as an illuminant for the dark room. A couple of rubber trays, solution bottles, either of celluloid or in corrugated protected cases, graduates, the necessary chemicals (which can be obtained in compressed form as capsules or tabloids), printing frame, and some ready sensitized paper will prove sufficient for all the exigencies of hasty field work. A champagne basket, which has been covered with two thicknesses of painted canvas to render it waterproof, forms a very suitable packing case which can not be broken, and will readily fit almost any load that can be put on a pack mule. A couple of months' supplies may be carried in the basket, and will not weigh more than fifty or sixty pounds, especially if cut films are used instead of glass.

Organization for Field Work. There should be attached to each divisional headquarters a photographic section supplied with a dark tent and only such apparatus as is necessary for its proper operation, and to each brigade headquarters a commissioned officer and two or more noncommissioned officers who have been specially instructed in this character of work, who should be equipped with a kit for hasty work and some substitute for a dark room, and to whom the double holders or roll holders may be sent in by operators in the field for immediate development in case of emergency. It may also be advisable to attach a couple of instructed men to such cavalry regiments as are detailed for outpost duty, or when with the contact squadrons.

Topographical Work. In reconnoissance and topographical work the pencil, prismatic compass, and protractor will yet hold their own, but the camera will prove of great value in a hilly, broken country, especially for panoramic work. The camera will always be of great value to the intelligence bureau of the staff in the

field for reproducing and multiplying copies of already existing maps, and officers sent on special duty can be supplied with such copies in an hour's time.

Carrier Pigeons. Photography is of great value in the reproduction of dispatches intended for scouting, messenger, and for carrier pigeons, and in this connection I shall quote the remarks of Gaston Tissandier:

No one can have forgotten the service rendered by balloons during the siege of Paris, nor the wonderful part played by carrier pigeons, which brought to the besieged city news from the outer world. But these birds, however strong they might be, could only carry with them very light burdens through the air. A thin sheet of paper two or three inches square was all the load that could be intrusted to these winged messengers. But how write orders, send dispatches, give precise instructions in such a minute letter? The most able caligrapher could hardly make it contain the letters in a single page of a printed volume. Microscopic photography came to the assistance of the besieged; it solved the difficulty as no other art could have done; it reproduced on a film of collodion weighing less than a grain more than 3,000 dispatches, that is to say, the amount of sixteen pages of folio printed matter. * * * Several of these films, representing a considerable number of dispatches, were rolled and inclosed in a quill about the size of a toothpick. This light and novel letter box was attached to the tail of a pigeon. * * * Each pigeon could carry twenty films in a quill, the whole not weighing more than fifteen grains. * * * Thirty or forty copies of the microscopic dispatches were usually printed and sent by as many pigeons. More than 100,000 of them were thus sent to Paris during the siege. As soon as the small tube was received at the telegraph office MM. Corun and Mercadier proceeded to open it with a knife. The photograph films were carefully placed in a small basin of water, in which were put a few drops of ammonia. In this liquid the dispatches unrolled themselves. They were then dried and placed between two plates of glass. It then only remained to lay them on the stage plate of a photo-electric microscope.

Outline of Instruction. The operations and principles which follow in the succeeding chapters give the operator the various processes fully enough to master the technical details, and when in the field his common sense and ingenuity will many times have to serve in place of chemicals and apparatus. Details have been avoided, but the essential characteristics of the apparatus necessary will be found in the subsequent chapters, and

there is one cardinal fact which the author desires to invite attention to, and that is the necessity of having all field equipments of a standard pattern, whose parts shall be interchangeable, thereby avoiding confusion and annoying delay.

CHAPTER I.

PHOTOGRAPHIC OPTICS—LIGHT—SPECTRUM—LENSES AND THEIR PROPERTIES —FORMATION OF IMAGES—SPHERICAL ABERRATION, ITS CORRECTION AND THE USE OF STOPS—ACHROMATISM—DISTORTION—EQUIVALENT FOCUS—CLASSIFICATION AND TESTING OF LENSES.

Light. Modern research seems to prove that light is the result of certain kinds of vibration in the ether which is supposed to pervade all space. Certain kinds of transverse vibration in this ether are recognized by our sense of vision as light. These vibrations are periodic, that is, they are repeated after a definite interval of time, called periodic time; the motion of the molecules of ether is called wave motion, the distance between two molecules which are similarly situated with respect to each other is called the wave length, while the maximum distance that the molecule is displaced from a position of rest is called the amplitude of vibration. The vibrations are transverse, that is, they are at right angles to the direction in which the original displacement is produced.

Spectrum. If a beam of light from the sun or the electric arc is allowed to fall upon a glass prism and the beam as it emerges from a prism is intercepted by a screen as in fig. 1, we will observe

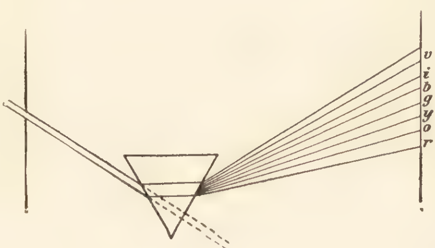


FIG. 1.

that the beam has been bent from its straight course through the prism toward its base. This deviation of light from a straight line is called refraction. The beam, when seen on the screen, is no longer white, but is composed of seven colors, red, orange, yellow, green, blue, indigo, and violet, and the beam is wider than it was at incidence. This broadening of the beam is called dispersion. The light which was originally white has now been separated into seven colors called prismatic, and the image on the screen is known as the spectrum. If the light had been one-colored (monochromatic or homogeneous) we should have observed deviation but no dispersion. If this spectrum be examined it will be discovered that beyond the red, or, as it is called, in the ultra red, the heat is greater, and in the ultra violet chemical action will be found to take place with great ease and rapidity. So it is to be observed that the spectrum can be separated into three grand divisions; the ultra violet or place of the chemical or actinic rays, the visible or place of the light rays, and the ultra red or home of the heat rays. It must not be understood that there is no heat or actinic action in the visible part of the spectrum, but each of the three grand divisions is the seat of the maximum effect of its characteristic rays. The vibrations are all of the same kind and differ only in amplitude and wave length. The wave length increases from the ultra violet to the ultra red, which indicates that both deviation and dispersion depend on the wave length, while intensity depends on amplitude alone.

Reflection; Refraction; Lenses.

When light falls on a transparent body part is reflected and part is refracted. The angle which the ray makes with the normal, or perpendicular, to the surface at the point of contact is known as the angle of incidence, and the angles which the reflected and refracted rays make with the same normal are known respec-

tively as the angle of reflection and refraction. The reflected ray makes the same angle with the normal as the incident ray, while the refracted ray, when passing from a rarer to a denser medium, is bent toward the normal, and vice versa; the denser the medium into which the ray passes the greater is the deviation. This law allows us at once to understand the action of a lens, which may be defined as a transparent medium that from the curvature of its surface causes the rays of light traversing it to either converge or diverge. The ordinary lenses have either spherical surfaces or a combination of spherical and plane surfaces. This combination will give rise to six classes (fig. 2); *a*, double

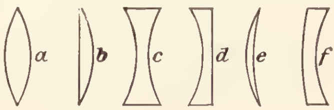


FIG. 2.

convex; *b*, plano convex; *c*, double concave; *d*, plano concave; *e*, converging, and *f*, diverging meniscus. Those lenses which are thicker at the center than at the edges are converging or concentrating lenses, and those which are thicker at the edges than the center are diverging.

Focus; Optical Center. The focus of a lens is the point where the refracted rays or their prolongation meet; if the rays themselves intersect after refraction the focus is real, and if their prolongations meet, the focus is virtual. The line passing through the centers of curvature of the two surfaces of a lens is called the principal axis and contains a point known as the optical center, which has the property by virtue of which, if a ray passes through it, the ray will not be deviated. The optical center can always be found by drawing two radii parallel to each

other, one from each center of the curvature of the surface until the radii intersect their respective surfaces, then draw a line joining these two points. The intersection of this last line with the principal axis will give the optical center.

Image; Conjugate Foci.

All photographic combinations of lenses are equivalent, as far as the formation of an image is concerned, to a convex lens, and a knowledge of the properties of this lens will enable us to understand the action of any photographic lens or combination. Let AB be the section of a double convex lens and C and D, fig. 3, be the centers of curvature of the two

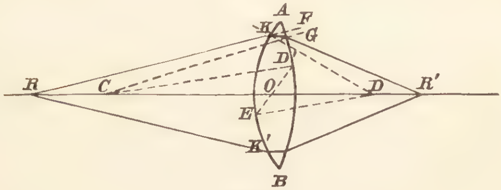


FIG. 3.

surfaces. Draw the lines CD′ and DE from C and D parallel to each other, then join D′ and E by a straight line. The point O will be the optical center of the lens. Let us take a point, R, on the principal axis as a source of light, the ray RD passes through the optical center and is not deviated. The ray RK on striking will be refracted in the direction KG toward the perpendicular to the surface KD in accordance with the law of refraction, as glass is denser than air. On emerging at G it is refracted away from the perpendicular to the surface CG, since it passes from a denser to a rarer medium, and will intersect the ray RD at the point R′. In a like way the ray RK′ will be found to intersect the ray RD at the same point, R′, which is the focus for all rays coming from R. The point R′ is said to be the image

of the object R, and when the two points are considered together they are called conjugate foci. If the incident beam is composed of parallel homogeneous light, the rays will all be brought to a focus at a point on the principal axis, called the principal focus of the lens, and the distance of this point from the optical center is the principal focal length, which is always a fixed quantity for any given lens.

Law of Foci. There is a fixed relation between the principal focal length of a double convex lens and the position of the image of the object which may be expressed as follows: $\frac{1}{i}=\frac{1}{f}-\frac{1}{o}$, in which i and o are the distances of the image and object respectively from the optical center and f the focal length, from which we see that for all positions of the object from an infinite distance away from the lens to double the principal focal distance, the image will be on the other side, between a distance equal to the principal focal length and double this length. These are the limits of the image and object in the ordinary cases when photographs are taken. The position of object and image in enlarging will be referred to later. If we place this expression in the following form: $i=\frac{of}{o-f}$, and suppose the object to remain the same distance from various lenses, it will be seen that the image will be closer to the lens which has the shorter focal length. The principal focal distance, or, briefly, the focal length of the lens, depends on the curvature of the surfaces, and the greater the curvature the shorter the focal length.

Formation of Image. Let us now see how an image is formed by a convex lens, and suppose that CD is the section of a double convex lens (fig. 4), O the optical center, and AB an object at a greater distance from the

optical center than double the focal length. Rays will pass out in all directions from the object and some will fall on the lens. A ray from A will pass through the

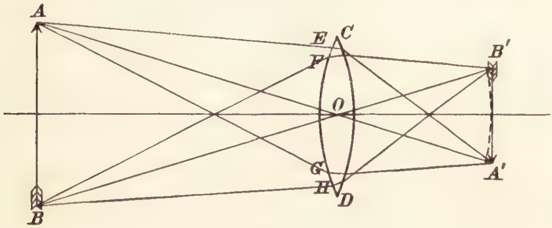


FIG. 4.

optical center and will not be deviated; others will be incident at various points, for example, E and G, and if we apply the law of refraction, we will find that AE and AG will intersect each other and AO at the point A′, provided we do not consider the figure of the lens, forming one point of the image A′ B′; similarly for rays from other points of the object, as for example B, we can construct the focus B′ and thus obtain the image A′ B′, which is inverted and smaller than the object AB. The relative size of the image and object will be directly as the conjugate foci, and these can be found at once from the equation of the lens.

Spherical Aberration. If, however, we consider the form of the lens, we will find that all the rays emerging from one point on the object are not brought to the same focus, because the rays incident on the edges of the lens are refracted to a greater extent than those falling on the center, and will be brought to a focus at a shorter distance from the lens than those passing through the central part. This confusion or wandering of the foci from one point is called spherical aberration, or aberration of form, and is due solely to the geometrical form of the lens.

Distortion of Image. In the above figure, considering the shape of the lens, the rays AE and AO have one focus, and the rays AG and AO another—similarly for the rays from all other points of the image—so it will be impossible to have it clearly defined, no matter in what position a ground glass or screen should be placed. This defect is corrected by the use of a stop placed in front of the lens so as to permit only the rays coming from the central part of the object to impinge on the central part of the lens, and the rays proceeding from the edge of the object to strike only the marginal part of the lens, as is shown in fig. 5, the dotted lines

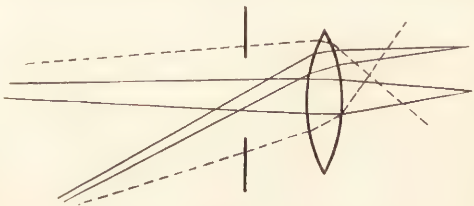


FIG. 5.

indicating the rays that would cause confusion. It is to be observed that the image will be curved as is shown by the dotted lines in fig. 4; and the reason is evident, for the rays proceeding from the ends of the object will be brought to a focus nearer the lens, as they are refracted to a greater extent than those coming from the central part. This departure of the image from a plane surface is said to be due to the curvature of the field, and the image is a distorted one. When this distortion is corrected, the lens is said to have a flat field. The method used to correct this defect will be explained later.

Stops. A stop also produces depth of focus, that is, it permits the images of both near and distant objects to be clearly defined on the ground glass, the smaller the stop the greater the depth

of the focus. This is easy to understand, as the smaller the stop the greater the number of oblique rays are cut off from the lens, and the angular opening of rays after passing their foci is smaller, so that the ground glass can be moved a greater distance without producing confusion, as may be understood from fig. 6, where it

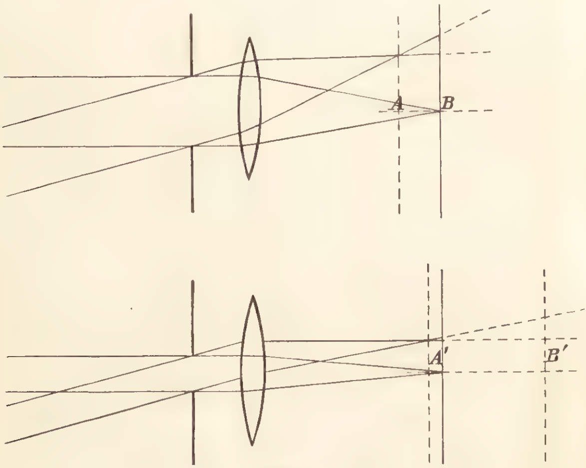


Fig. 6.

will be observed that the ground glass can be moved from A′ to B′ a greater distance than from A to B before the rays have the same spread on the ground glass, or, in other words, before the confusion of the image is the same.

Effective Area and Stop Numbers. The effective area of a stop placed in front of a single lens depends on its geometrical area, which varies as the square of the diameter, and the square of the focal length, since the brightness of the image depends on the cone

of light admitted by the stop. The effective area is conventionally written as follows: $\left(\frac{f}{d}\right)^2$, where f is the focal length and d the diameter of the stop. In case the stop is placed between two lenses of a combination, the diameter of the stop can no longer be used in the expression for the effective area, as the rays, after passing through the first lens, are concentrated and more light passes through it than if the stop were in front of the lens. The proper diameter to be used can be found by focusing on a distant object; then, replacing the ground glass by a piece of cardboard with a small hole in the center, hold a candle near it, and measure the diameter of the circle of illumination seen in the front lens. This diameter and the distance from the cardboard to the stop are the quantities to be used. The rapidity of the lens depends upon the amount of light admitted by the stop, and is directly as the effective area of the stop. In all lenses now sold the stops are furnished by the manufacturers, and their location on the lens tube is fixed. There are three kinds of stops usually found in the market: (1) separate sheets of metal with circular holes in the center which are inserted in a cell located in front of a single or between the lenses of a combination; (2) the revolving diaphragm, which consists of a circular sheet of metal or ebonite so attached to the lens tube that by revolution the various circular openings cut in the sheet can be placed in their proper position; and (3) the iris diaphragm, which is of metal leaves so constructed as to expand and contract in a way similar to the movement of the iris of the eye. All stops are now usually numbered in the following series: 8, 11, 16, 32, 64, etc., and are referred to as $\frac{f}{8}$, $\frac{f}{11}$, $\frac{f}{16}$, etc., the number showing what part of the focal length the diameter of the stop

is; for example, if the stop number of a 10-inch equivalent focus lens is $\frac{f}{16}$ the diameter is 0.625 inch, but if a stop of this diameter, namely, 0.625 inch, were used with a $12\frac{1}{2}$-inch equivalent focus lens, its stop number would be $\frac{f}{20}$; or else, in a series known as the "U. S." or Universal System, in which U. S. No. 1 corresponds to $\frac{f}{4}$, No. 4 to $\frac{f}{8}$, No. 8 to $\frac{f}{11.31}$, No. 16 to $\frac{f}{16}$, No. 32 to $\frac{f}{64}$, etc. To find out which system the stops are numbered in, measure accurately the diameter of the various stops—if they are the eighths, sixteenths, thirty-seconds, etc., parts of the focal length, the system is the F system; if not, the U. S. system. These numbers permit us to compare the working of different lenses. The stop number and effective aperture, however, must not be confounded.

Chromatic Aberration. We have now seen how the visible object is formed, but we know that the actinic rays produce the greatest chemical action and are the ones which form the photographic image on the sensitive plate. Evidently, in a camera, the actinic and visual rays should coincide or else, when one set of rays is in focus, the other would be out of focus on the sensitive plate. In what has been said about the visual image we have supposed that the light was monochromatic, or homogeneous. Let us see what

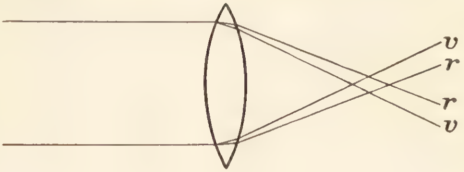


FIG. 7.

will happen if the light is polychromatic, say, for example, sunlight, and let a beam of sunlight be intercepted on a screen after passing through a double convex lens. It will be observed, as in fig. 7, that the violet rays are brought to a focus nearest the lens, and the red farthest away, and circles of light will be seen on the screen; this wandering of the colored rays from a common focus is called chromatic aberration and depends on the dispersive properties of the material of which the lens is made. Here is a defect that can not be corrected by a stop, but as the refractive and dispersive properties of a substance do not vary together, it is possible to combine two substances, one with high refractive and low dispersive properties and the other with the reverse properties. If proper curves are given to them they will correct each other, thereby producing coincidence of the visible and chromatic foci. Such a combination gives an achromatic lens which is usually composed of a double convex of crown glass cemented to a diverging meniscus of flint glass, as shown in section in fig. 8. This combination is not absolutely achromatic, but sufficiently so for all photographic purposes.

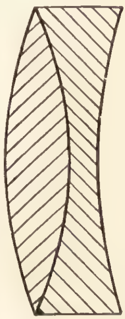


FIG. 8.

Distortion. If a single lens is used in a camera, and the camera focused on a building, the outlines of the building will be curved lines, and the image will be distorted. Take a series of squares ruled on cardboard and with a single plano-convex lens focus on this cardboard; the image will be composed of curved lines, the curves being convex or concave, as the plano or convex surface of the lens is turned toward the object, as seen in fig. 9. The terms barrel and pincushion distortion are given to the images in these two

cases. If, however, the image was formed by a combination of these two lenses placed at a suitable distance

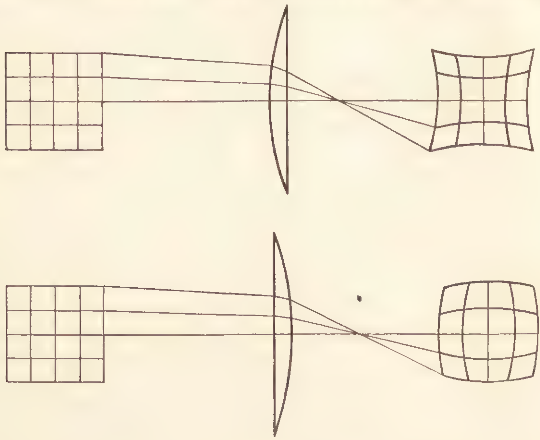


Fig. 9.

apart, each lens would correct the distortion of the other, and the image would be rectilinear, as in fig. 10.

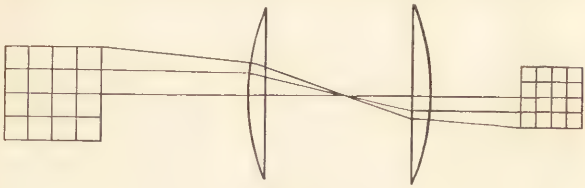


Fig. 10.

Condition for Nondistortion Combinations: Angle of View. The condition for nondistortion is that the rays on emerging should be parallel to their course when entering the lens. When two or more lenses are used together to form an image they are known as a combination and are called a doublet, triplet, etc., depending

on the number of elements. Each element is usually composed of two lenses of different shapes, one of crown and one of flint glass, or both of flint glass of different densities, cemented together to correct the chromatic aberration. A combination is said to be symmetrical when the elements have the same size and shape, but it is not to be supposed that symmetry is at all necessary to obtain a large effective aperture, wide field, or anastigmatism. The angle of view, or width of field, depends upon the focal length, which in turn depends on the radii of curvature of the different surfaces. The angle of view is found by dividing one-half of the extreme width that the lens will cover on the ground glass by the focal length. This will give the natural tangent of half the angle in view. Enter a table of natural tangents with this quantity and find the angle corresponding to it, multiply this angle by two, and the result is the angular width of the field. To find the largest-sized plate that a lens will cover, take the diameter of the circle of illumination, when the ground glass is at a distance from the optical center equal to the focal length. This diameter will be the diagonal of the largest-sized plate that can be used with the lens. It is difficult to make a rigid classification of lenses with respect to angular width of field, but the classification given by J. Traill-Taylor in his excellent work on lenses seems the best; that is, lenses with an angular field less than 25 degrees are narrow-angle lenses; up to 45 degrees, medium-angle lenses; and beyond 45 degrees, wide-angle lenses.

Equivalent Focal Length. The equivalent focal length of a combination is the focal length of a convex lens which would, when used in place of the combination, give the same-sized image, and consequently the equivalent focal length of a combination changes with every variation of position of the object and image, but the combination obeys the same law for conjugated foci

as a single lens, and knowing the equivalent focal length of a combination for any given position of the object, we can calculate the position of the image by use of the equation given before. The optical center of the combination is not a fixed point as is the case with a single lens, nor is it, as frequently supposed, at the mechanical center of the combination, or at the point where the stops are located, but changes its position with a change of the position of the object. The equivalent focal length of a combination may be determined as follows: Draw two vertical lines on ground glass at a convenient distance apart and at equal distances from its center, then place the camera on a piece of drawing paper on a level table, and focus on some well-defined distant vertical object, such as the flagstaff or the corner of a building. Make the image of the flagstaff or building coincide with one of the lines drawn on the ground glass, and, with one side of the camera as a straightedge, draw a line on the paper. Now rotate the camera until the image coincides with the other line drawn on the ground glass, and draw a line on the paper, using the same side of the camera as before. Prolong these two lines until they meet, and their intersection is evidently the optical center of the combination. Bisect the angle between these lines and draw the bisectrix. Slide a graduated ruler along the bisectrix, keeping it perpendicular to this line, until the opening between the two first lines drawn is equal to the distance between the two lines on the ground glass. Mark where the edge of the ruler crosses the bisectrix, measure the distance between this point and the vertex of the angle, and this distance is the equivalent focal length of the combination. The focal length of a single convex lens may be obtained by focusing on an object and moving the lens until the image and object have exactly the same size, then one-fourth of the distance

between the image and the object is the principal focal length.

Classification of Photographic Lenses..

Lenses are usually divided into three classes according to the use to which they are put, as follows: Portrait, landscape, copying, and architectural. A portrait lens is a combination of large aperture as compared to its focal length, so as to admit a large volume of light in order to make portraits in the subdued light of the studio. They are nearly all constructed after the original form devised by Professor Petzval, of Vienna, which consists of a nonsymmetrical achromatic combination, whose front element is a plano convex of crown and a plano convex of flint, and the back element a diverging meniscus of flint and double convex of crown. Portrait lenses are aplanatic, that is, they can be used without a stop, but a stop is necessary to obtain the best results. Such lenses have but little depth of focus and a narrow field of view, but work with great rapidity. Landscape lenses are those which are used for general view work, where great flatness of field and lack of distortion are not required. They may be divided into two classes, single achromatic lenses and combinations. The single lens is of the achromatic converging meniscus type, the flatter the lens, the greater the rapidity, as a larger aperture may be used. The single landscape lenses, of which there are quite a number in the market, possess several defects, namely: They produce distorted images, are slow, have a moderate angular view, but when used with small stops have considerable depth of focus and make crisp, sparkling negatives. They are nonaplanatic and must always be used with stops. The landscape combination corrects these defects to a greater or less extent and merges into the third class. When architectural work or copying is to be done it is absolutely necessary that the combination should be achromatic and anastigmatic, and it is very desirable that it should

be rapid. There are quite a number of rapid rectilinear or anastigmatic combinations on the market; the best, however, are those made from the celebrated Jena glass. A teleo-photo attachment to a combination consists in the addition of a negative or magnifying element in the rear of the combination proper, so as to produce larger images of distant objects, and is extremely valuable for military purposes, but such an addition necessarily reduces the rapidity of the combination.

Testing Lenses. Photographic lenses should always be tested for the following: Flatness of field, anastigmatism, achromatism, definition, surface finish, striæ, air bubbles, and flare spot. To test the lens for flatness of field, set up the camera and focus, using a large-sized stop, on an object some distance away. Make the image on the center of the ground glass as sharp as possible, then rotate the camera till the image is on the edge of the ground glass. If the image is still sharp, the lens has a good flat field. To test for achromatism, place five or seven printed cards, which have also a serial number in black on them, in a row on edge about 10 feet from the camera and 6 inches apart, focus, using a large-sized stop on No. 3 or 4 (the center one), making the image as sharp as possible by examining it with a magnifying glass, expose a plate, and develop. If the center card is still the sharpest, the foci for the actinic and visual rays coincide, and the lens is practically achromatic. Anastigmatism is tested for by carefully leveling the camera, still using a large-sized stop, and focusing on the edge of a building, the crossbars of a window, or any other straight object, forming the image in the center of the ground glass. Then rotate the camera till the image comes to the edge of the ground glass, when all the lines should be perfectly straight. The definition may be tried by focusing with a large stop on the enameled face of a watch held in a bright light, when the divisions between the black

marks forming the figures II, III, IV, and XII and the divisions on the second-hand dial should be clearly shown, otherwise the definition is not good. The surface of a lens when viewed with a magnifying glass in a room illuminated by artificial light should show no signs of granulation, otherwise the lens has not been completely polished. To test for striæ, turn a gas flame rather low, or use a candle, hold the lens a few feet from the light, so that the lens will appear as a mass of light, then move it slightly from side to side, rotating it at the same time. If there are any striæ, the light will not be uniform, and streaks will be seen. Air bubbles may be discovered by holding the lens up to the light and looking through it. These are not serious defects and act only as so many spots of opaque material. The flare spot is the image of the diaphragm and produces on the ground glass a circle of light of greater intensity than the general illumination of the plate. This may be tested for by covering the lower half of a window and focusing on it, using, in this case, the different-sized stops; if there is a flare spot, it will appear in the middle of the ground glass.

CHAPTER II.

Photographic chemistry, development, fixing, and intensification—Composition of matter and chemical formulas—Actinic action and the formation of the chemical image—Theory of development and intensification—Dark room—Process of development and fixing the chemical image and formulas for same; pyrogallic acid, hydrochinon and eiconogen, metol—Development of bromide paper—Reduction of density—Defects in negatives.

Composition of Matter. If a piece of wood be divided continuously until it can not be further divided without losing its identity, the remaining piece is called a molecule, and, if this molecule be further divided, it will be found to be composed of two gases, hydrogen and oxygen, and a solid, carbon. The component parts of a molecule are called atoms. The substances whose atoms make molecules are known as elements, as they can not be divided into simpler substances. The union of two or more elements gives a chemical compound and the reason for their combination is owing to the affinity or liking of each for the other. When two elements which have an affinity for each other are brought together, they will enter into a combination and form a third substance whose properties are entirely different from those of the two elements; for example, the two gases, hydrogen and oxygen, under certain circumstances, combine together and form water, which has properties entirely different from the component elements. When two elements combine or two compounds interchange elements on account of their various affinities for each other a chemical reaction is said to have taken place. This action may be illustrated in the following way: Suppose that John has an apple and James a pear, and that John likes pears better than apples and is stronger than James; they meet; John takes the pear from James and gives him the apple. This is the action when two

substances which are capable of reacting on each other are brought together. A part of the first combination may have a stronger affinity for a part of the second than it has for the remainder of the first and it unites with that of the second, leaving the other parts of both combinations to unite together, thus forming two new substances. When compounds are in solution, reaction takes place with greater ease than if they were solids, as the molecules can meet each other with greater facility. Heat assists in quickening chemical action and cold retards it, a most important fact which should always be remembered.

Chemical Formulas. The chemical composition of various substances is indicated by formulas which show the kind and number of elements in a compound; for example, AgCl represents chloride of silver and indicates that the molecule of chloride of silver is composed of one atom of silver and one of chlorine (the chemical elements and their symbols are given in the appendix). A reaction is expressed in the form of an equation whose left-hand side shows the compounds before the interchange takes place, and the right-hand side, the result of the interchange ; *e. g.*, if a solution of common salt, symbol NaCl, be added to a solution of nitrate of silver, symbol $AgNO_3$, the mixture of the two solutions would be represented as follows : $NaCl + AgNO_3$. When this is done a white precipitate is observed, and this precipitate is chloride of silver, AgCl; nitrate of sodium, $NaNO_3$, will be found in the solution. The entire operation can be indicated as follows:

Chloride of sodium and nitrate of silver gives chloride of silver and nitrate of sodium.

$$NaCl + AgNO_3 = AgCl + NaNO_3.$$

Actinic Action of Light. Nearly all substances undergo some change when exposed to the action of light. The change may be visible, as when we see certain colors fade under the action of sunlight, or may not

be visible to the eye until we submit the substances to the action of certain chemicals called developers. If chloride of silver be exposed for some time to the action of sunlight, it will be observed to darken, but if exposed for a brief length of time no visible action of the light will be observed; however, we can show that a similar change has taken place to a less degree by the application of certain chemicals, which will render the change visible, and we are led to believe that the only difference in the two cases is due to the relative number of molecules affected. When a change is produced in this way and an image is formed, it is called the photographic image, but the term is usually applied only to the invisible image formed on a plate or film containing some salt sensitive to the action of light. The salts of silver are ordinarily quite sensitive to the actinic rays, and those usually employed are the bromide, AgBr, the iodide, AgI, and the chloride, AgCl. The three elements, bromine, iodine, and chlorine, are called halogens, that is, salt makers, and their combinations are known as haloids. When light acts on the haloid salts of silver, there is every reason to believe that the haloids are reduced to subhaloids, or salts containing less of the halogen than before, and part of the halogen is set free; as, for example, when light acts on two molecules of bromide of silver, the molecules are broken up, the two atoms of silver unite with one of bromine, forming one molecule of subbromide of silver and liberating one atom of bromine:

Bromide of silver gives subbromide and bromine.

$$2AgBr = Ag_2Br + Br.$$

When a photographic image is formed by the reduction of the haloid of silver to the subhaloid, the high lights of the object produce the greatest density, the shadows the least, while the half tones vary between these limits, so when the plate is developed the result is called a

negative, for the bright lights appear the darkest and the shadows the lightest parts of the plate.

Development. Modern dry plates consist of an emulsion on glass of gelatin containing bromide of silver and sometimes iodide. The emulsion may also be mounted on celluloid or paper giving what is known as films or bromide paper, but in all cases the photographic image is formed in the same way. The process of rendering the photographic image visible is called development, and the combination of chemicals used for this purpose is known as a developer. For dry-plate work nearly all developers now used are alkaline. The alkaline developer consists of two essential parts, an easily oxidizable, or reducing agent, such as pyrogallic acid, eiconogen, hydrochinon, metol, amidol, etc., and some one of the combinations of the alkalies, such as ammonia, caustic potash, caustic soda, carbonate of sodium, carbonate of potassium, etc., together with a preservative, for example, sulphite of sodium. When the bromide of silver is exposed to the action of the light, only a small part is reduced to subbromide, and if this be subjected to the action of pyrogallic acid, which may be considered typical of all the easily oxidizable substances used in development, very little action will be observed to take place; if, however, a little alkali, say carbonate of soda, be added, a blackening of the parts exposed to the action of the light will be observed. This action is due to a deposit of metallic silver in the gelatin. Experiment has proved that bromide of silver does not exist in molecular contact with freshly deposited metallic silver, so when the subbromide, produced by the reducing action of the light, is split up into bromine and silver, the silver at once recombines with a part of the bromide not affected by the light, forming fresh subbromide.

Pyrogallic Acid Development. Silver and bromide of silver gives
$Ag + AgBr =$
subbromide of silver, which is in turn
Ag_2Br
reduced and the process is continued, the image growing from the surface downward and at the close is visible on the back of the plate. The action of alkaline developers may be described as follows: The subbromide of silver is reduced to the metallic state, the liberated bromine combines with the sodium of the carbonate forming bromide of sodium or possibly a more complex compound, and while the pyrogallic acid is oxidized by the remaining parts of the carbonate of sodium, giving a very complex compound whose exact composition is not known. This action, in the language of a chemical equation, is possibly as follows:

Pyrogallic acid and subbromide of silver and car-
$C_6H_6O_3 + 2Ag_2Br +$
bonate of sodium gives silver and bromide of sodium and
$2Na_2CO_3 = 4Ag + 2NaBr +$
$Na_2C_8H_6O_9$, the $Na_2C_8H_6O_9$ being the result of the oxidation of the pyrogallic acid, the equation being understood as showing the rationale of the reaction and not giving a quantitative result. If the developer is working too fast, that is, if the high lights are becoming too dense, while no details are showing, or if the plate has been overexposed, it is necessary to retard the action of the developer, which may be done by the addition of a restrainer (bromide of potassium), which prevents the too rapid change of the unaltered bromide to the subbromide by forming with it a compound which is much less easily attacked by the developer. The developer can be hurried along by the use of more of the alkali, and the density increased by the addition of more of the reducing agent.

Ferrous Oxalate Development. The ferrous oxalate developer which is now used for bromide paper alone is similar in its action to the alkaline developers. Ferrous

oxalate is prepared by adding a saturated solution of ferrous sulphate to one of neutral oxalate of potassium, the iron and potassium changing places and forming ferrous oxalate and sulphate of potassium.

Oxalate of potassium and ferrous sulphate gives ferrous oxalate and sulphate of potassium.

$$2KC_2O_4 + FeSO_4 = Fe(C_2O_4)_2 + K_2SO_4.$$

The ferrous oxalate unites with the subbromide of silver, reducing the silver to the metallic state, the liberated bromine unites with part of the iron, giving ferrous bromide, while the rest of the compound produces ferric oxalate.

Subbromide of silver and ferrous oxalate gives silver and ferrous bromide and ferric oxalate.

$$2Ag_2Br + 3FeC_2O_4 = 4Ag + FeBr_2 + Fe_2(C_2O_4)_3.$$

The products of the combination have considerable reducing properties themselves, and their action must be restrained by the addition of bromide of potassium.

Fixing the Image. When the development is completed the back of the plate will be observed to be of a light yellow color, which is due to the presence of the unaltered bromide and iodide of silver, which are nearly as opaque to light as the metallic silver itself, and if a positive is made from the negative nothing will print through. It is necessary to remove the unaltered bromide, and this process is known as fixing. If the negative be subjected to the action of a solution of hyposulphite of sodium the silver salts are converted into hyposulphite of silver, which is very easily soluble and dissolved from the emulsion, leaving only the reduced metallic silver, which is not affected by the action of the sodium hyposulphite.

Orthochromaticism. The actinic rays have their maximum effect in and beyond the blue end of the spectrum, reducing more of the bromide to the substate and giving greater density than yellow and red

rays of the same intensity. It naturally follows, then, that the negative can not reproduce color values. When a print is made the blues appear too light and the reds and yellows too dark. This may be obviated by the use of certain dyes, such as eosine or erythrosine, added to the emulsion. These dyes either combine with the silver and form organic salts which are capable of being reduced to a subsalt by the rays from the red end to which they are sensitive, or they form, with the bromide of silver, mixtures called lakes which are affected by the red end of the spectrum. When development takes place the resulting density depends on the color value as well as on the intensity of the light. Plates treated in this manner are called orthochromatic and reproduce to a certain extent true color values, but such reproduction will be greatly improved by the use of a color screen which usually consists either of yellow or red glass or a transparent cell containing yellow or red liquid which absorbs part of the energy of the rays from the blue end of the spectrum reducing their rapidity to an equality with those from the red end, so that the resulting density not only depends upon the variation of light but also upon the variation of colors.

Increase of Density. Owing to certain causes the negative after development may not have sufficient density to be a good printer. It is possible to increase the density of the negative, or intensify, as it is called, by causing the deposit of some opaque metallic salt on the silver or changing the metallic silver to a salt whose density is greater, for example, by the use of mercuric chloride (corrosive sublimate) followed by a subsequent bath of strong ammonia. When the solution of mercuric chloride is poured over the negative a whitening of the entire surface is seen to take place and this is due to the formation of chloride of silver.

Mercuric chloride and silver gives mercurous chloride and chloride of silver;

$$HgCl_2 + Ag = HgCl + AgCl$$

and when the strong ammonia is added the chloride of silver is blackened and the density increased.

Exposures.

Skill in development is only acquired by practice, and then good results can only be obtained when the plate has had the proper exposure. The exposure depends on the sensitiveness of the plate, the intensity of the light, the nature of the object, and the effective aperture of the lens. The various plates supplied by the makers are given a sensitometer number which indicates the comparative rapidity of the various plates of the same maker. The highest are the most sensitive, and there is a difference of from $1\frac{1}{8}$ to $1\frac{1}{2}$ times the sensitiveness between each number of the series; the labels on the boxes indicate the use to which the plates can be applied. A normal exposure may be understood to be one that will give, after proper development, a negative in which the variations of light and shadow are similar to those in the object photographed, and the details in the shadows capable of being brought out clearly enough to show up well after printing. An under-exposure is one where the plate has not been exposed long enough to get sufficient contrast to bring out the half tones and details in the shadows and should be relegated at once to the waste pile, as no subsequent treatment will produce a normal negative. An over-exposure, if not too great, may be made into a very acceptable negative, and it is the custom of a good many photographers to slightly overexpose for detail, and by proper manipulation of the developer obtain a normal printing negative.

Dark-room Light.

The formulas which follow are those recommended by the various authorities and the author has found them very satisfactory. For the beginner nothing is more conducive to failure than to keep shifting from one developer to another. Learn how to use one developer first, and experience will show that this one will suffice for ringing all the changes

from long-time exposures to instantaneous shots. Failures are the best teacher as there is a cause for each, and if this cause be discovered and remembered, the experience gained will serve as a guide in all similar cases. In the dark room, which should be properly ventilated, no matter how small, and supplied with a sink and running water if possible, cleanliness is the cardinal virtue. Dirt and dust are the two most deadly enemies of good results. If work is to be done by daylight, the dark room should have a window facing north and supplied with a pane of ruby and orange glass or glass covered with two thicknesses of paper stained with chromate of lead or two thicknesses of orange envelope paper. All other openings must be made perfectly light-tight. There should be plenty of shelf space and only the necessary chemicals for developing, fixing, and intensifying, together with trays, graduates, etc., should be kept in the dark room. All other apparatus, plates, and stock of chemicals and paper should be kept in a separate storeroom, which should be dry and well ventilated. If artificial light is to be employed, use may be made of any one of the many good lanterns now in the market, the author having found Carbutt's Multum in Parvo eminently satisfactory for all operations in the dark room.

Safety of Light. If there is any suspicion as to the safety of the light in the dark room it must be tested by placing an instantaneous plate in a holder, withdrawing the slide halfway and allowing it to remain exposed, then develop and fix out. If there is no appreciable difference in the density of the two halves of the plate after three or four minutes' exposure the light is safe, but it is advisable when developing very rapid and orthochromatic plates to keep them covered up and examine only from time to time to watch the progress of the development. In ascertaining the density of the negative during development always turn the film side

of the plate toward the light as there is less danger of fog, since the top layer of a film already developed protects the parts lying below from any chance of fog if the light is unsafe.

Process of Development. To develop a plate, which should be thoroughly dusted before placing in the holder, remove it from the holder, handling it by the edges and back, care being taken that the fingers do not touch the film side, brush the surface with a camel's-hair brush to remove all specks of dust, which if allowed to remain will produce pin holes in the negative. For beginners it is best to hold the negative under the tap till the surface has been thoroughly wetted, then place it in a tray, taking care that there are no air bubbles on the surface of the plate. Flow the developer over with a sweeping movement from the graduate and the wet surface of the gelatin will cause the developer to spread evenly. The tray should be given a slightly rocking motion to prevent air bubbles from settling on the plate. In fifteen or twenty seconds the high lights of the negative should begin to show up, except when using metol or in case of an instantaneous exposure. If the image suddenly flashes out, the plate has been overexposed, and the action of the developer can be checked by the use of ten or twelve drops of a ten per cent solution of bromide of potassium, or the developer should be diluted by a large volume of water. If after about twenty-five or thirty seconds the image does not appear, the plate is probably underexposed. The details should first be helped out by the use of more of the alkali and the density then increased by more of the reducing agent; experience alone will indicate the proper amount of each to be added. It will frequently happen that sufficient details are obtained, but there is not enough density to make a good printer, but this can be corrected by subsequent intensification. In case the high lights and the brighter half tones develop up correctly and then begin to thicken before the details come out in the rest of the image, it

is advisable to dilute the developer with from two to four volumes of water, allowing the weakened developer to work on the shadows while the high lights have their density increased very slowly. Sometimes it may be necessary to leave the plate for an hour or so in the weakened developer before the necessary amount of detail is brought out in the shadows. By this prolonged development good negatives may be made from subjects such as interiors which have great contrast even though they have been undertimed. In treating over-exposures use but very little alkali at first and considerable bromide till the plate acquires density; then sufficient alkali should be added to finish the operation. When in doubt as to the correctness of the exposure, it is best to start the development with old developer, as it can then be discovered whether the exposure is normal or not. The development should be continued until the detail is well out in the shadows and the image visible on the back of the plate, then remove the developer, wash under the tap for about a minute or so, place in the clearing and fixing bath. Let the plate remain in the fixing bath till about five minutes after all trace of the iodide and bromide of silver has disappeared from the back, wash in running water for at least three-quarters of an hour, then place in the rack to dry spontaneously.

Films. In developing films the tray with the film in it should be held under the tap, and the surface of the film swabbed over with a tuft of absorbent cotton, the tray then drained and the developer applied. After fixing and washing, the surface should be swabbed over with cotton, then placed for a short time in the following bath: 1 ounce glycerin, 20 ounces water; after this pass it through clean water and hang up by a clip to dry.

Preparation of Solutions. In preparing the solutions for development, distilled water should be used if possible. If not, use in the following order, filtered water

from melted ice, filtered rain water or water from the tap which has been boiled and filtered. Such boiling will precipitate most of the carbonate of lime that is present in nearly all water. Great care must be taken that the developing solutions are kept at a temperature between 65 and 70 degrees Fahrenheit. If in cold weather the solutions and water are lower than this in temperature the developer will work too slowly, and if higher than this, as in summer, too rapidly, and the negative will be ates, and solutions should be cooled down and kept at this flat and lacking in detail. In summer the trays, gradu- temperature, with ice if necessary, and in winter warmed slightly until they are 65 or 70 degrees. Warm solutions in addition to producing flat negatives will have a tendency to frill the plates.

Pyrogallic-acid Developer. Pyrogallic acid is one of the most valuable of the developing agents, and its proper use gives great control of the negative in all stages of development. A pyro developer, however, will not keep well unless preserved in well-stoppered bottles, and, when old, will stain negatives yellow. It is better when only two or three plates are to be developed at a time to make up the solution fresh for each batch of plates. To do this, dissolve in 4 ounces water the following:

Crystallized sulphite of soda	grains	120
Crystallized carbonate of soda	grains	60
Or, dry granular carbonate of soda	grains	30
Carbonate of potassium	grains	30

Then add 10 grains of Schering's or Merck's pyrogallic acid and 10 minims of a 10 per cent solution of bromide of potassium.

For under-exposures omit the bromide; for instantaneous exposures soak the plate in the alkali solution before pyro is added, then pour off, add pyro, and proceed with the development, which may take ten or twelve minutes. If at the end of this time the image is not fully developed, add about three volumes of water, cover the tray, and allow it to stand for about

three-quarters of an hour. If it is desired to keep stock solutions on hand, prepare the following:

Pyro Solution.

Distilled water	ounces	16
Oxalic acid	grains	15
Or, sulphuric acid	minims	15
Bromide of potassium	grains	30

Then add 1 ounce of Schering's or Merck's pyrogallic acid.

Alkali Solution.

Distilled water	ounces	16
Sulphite of sodium, crystals	ounces	4
Carbonate of sodium, crystals	ounces	2
Carbonate of potassium	ounce	1

The solutions should be kept in bottles with either glass stoppers or tightly fitting rubber corks. For a normal developer add 1 ounce of the alkali solution and 2 drams of the pyro to 4 ounces of water. For over-exposures soak the plate in the following for about two minutes: Water, 4 ounces; pyro solution, ½ ounce and 15 minims of 10 per cent solution of bromide of potassium; after soaking add 1 dram of alkali solution and more if necessary as the development proceeds. For instantaneous exposures, place the plate in 4 ounces of water and 1 ounce of the alkali solution and let it remain for 3 or 4 minutes, then pour off and add 2 drams of the pyro solution and a couple of drops of a 10 per cent solution of bromide. If the development is not complete in ten or twelve minutes proceed in the manner given above.

Hydrochinon and Eiconogen Developer. A combined hydrochinon and eiconogen developer keeps much better than the pyro and is less liable to stain the plates when old. Prepare the following stock solutions:

Solution No. 1.

Distilled water	ounces	32
Sulphite of sodium, crystals	ounces	4
Eiconogen	grains	320
Hydrochinon	grains	160

Solution No. 2.

Distilled water	ounces	32
Carbonate of soda, crystals	ounces	2
Carbonate of potassium	ounces	2

For instantaneous exposures take 4 ounces of water, 1 ounce of No. 1 and 1 ounce of No. 2; for normal exposures on rapid plates, 3 ounces of water, 1 ounce of No. 1 and ½ ounce of No. 2; for normal exposures on slow plates, 4 ounces of water, 1 ounce of No. 1 and ¾ ounce of No. 2.

Metol Developer. Metol when mixed up in a developing solution keeps better than any other reducing agent and may be used over and over again without fear of staining the negative, which is quite likely to happen when old pyro or hydrochinon and eiconogen developer is used. Metol has the advantage over these reducing agents in its power to bring out detail in underexposed plates without clogging the high lights. For use make up the following solutions: Call the first one Solution A.—Dissolve 50 grains of metol in 10 ounces of water, then add 1 ounce of crystallized sulphite of soda. Solution B.—Distilled water, 10 ounces, potassium carbonate, 1 ounce. Solution C.—10 per cent solution of bromide of potassium. For normal exposures, use 3 ounces of A, 1 ounce of B, and 40 minims of C; for snap exposures omit C; for over-exposures add 1 dram of C; for very rapid exposures (one-fiftieth of a second and under) use first 3 ounces of A, at about 90 degrees Fahrenheit, but not hotter, then add after image is coming well out ½ ounce of B. The old developer may be used five or six times by strengthening it each time with a couple of drams of A. With normal exposures the high lights begin to appear in from four to ten seconds, and the development is completed in three or four minutes. The negatives must be developed for density to a greater extent than with pyro or hydrochinon and eiconogen, as they lose density in fixing out. If there is a tendency to a fog more bromide must be added, but large quantities retard development. If there is an

apparent lack of density it can be increased by the use of more of B.

Clearing and Fixing Bath. After the negative is developed and washed, it should be placed in a clearing and fixing bath, which is prepared as follows: Dissolve 16 ounces of hyposulphite of soda in 48 ounces of warm water; 2 ounces of crystallized sulphite of soda in 6 ounces of warm water, add 1 dram of sulphuric acid to 2 ounces of water and pour into the solution of the sulphite, then add this mixture to the solution of the hyposulphite. Dissolve 1 ounce of chrome alum in 8 ounces of water and add to the preceding when the bath is ready for use. The bath will not discolor until after long use, and clears and hardens the negative at the same time. It is much superior to the plain hypo bath, which consists of 1 part hypo to 4 of water. The negative should be allowed to remain in this bath for about five minutes after all trace of the bromide of silver has disappeared from the back, when it should be washed for forty-five minutes in running water and then placed in the rack to dry spontaneously. In case it is necessary to dry the negative rapidly, flow over it two or three times methyl alcohol, which will take up all the water. In case the plain hypo bath is used, it is well after fixing and before washing to place the negative in a solution of alum for a short time to harden the film and to prevent frilling. In hot weather use the alum bath both before and after fixing.

Removal of Stains. If the negative after development with pyro or hydrochinon and eiconogen has a yellow stain, this may be removed by the following bath, which is used after the plate has been fixed and thoroughly washed: Water, 20 ounces; sulphate of iron, 3 ounces; sulphuric acid, 1 ounce; alum, 1 ounce.

Development of Bromide Paper. The following are instructions given by the Eastman Company for developing their Eureka bromide paper. Prepare the following solutions:

Solution A.

Oxalate of potash	pound	1
Hot water	ounces	48
Acetic acid	drams	3

Solution B.

Protosulphate of iron (ferrous sulphate)	pound	1
Hot water	ounces	32
Acetic acid	dram	½
Or, citric acid	ounce	¼

Solution C.

Bromide of potassium	ounce	1
Water	quart	1

To develop add ½ ounce of B to 3 ounces of A (never reverse this order of mixing) and 30 minims of C, and use cold. Place the paper in a suitable tray, soak in water till limp, then pour off water and flow on the developer. The image should appear slowly and develop up strong, clear, and brilliant. When the shadows are sufficiently black, pour off the developer and wash three times for a minute each in a clearing bath composed of 1 dram of acetic acid to 32 ounces of water (this clearing bath is to prevent the precipitation of iron from the developer on the film, and the consequent yellowing of the print); then rinse in pure water and place in the fixing bath of three parts hyposulphite of soda to sixteen parts of water. Allow the print to fix for ten minutes, then wash in running water for about two hours, and hang up to dry. Fresh developer must be used with each batch of prints.

Metol for Bromide Paper. Metol is an excellent developing agent for bromide paper and requires much less exposure than the ferrous oxalate developer. "The best plan is to use developer fairly strong; if this is done the tones will be very good. If the developer as a whole is much diluted, or if the alkali is much reduced in proportion, or if too much bromide be added, the tones will be most too gray and less black than is usually desired." If the paper has a tendency to blister,

treat with a bath of 2 ounces of common salt to 1 quart water.

Intensification. If the negative does not possess sufficient density for printing, it should be placed, after a thorough washing to eliminate the last traces of hyposulphite of soda, which if present will produce yellow spots on the negative after intensification, in a saturated solution of corrosive sublimate (mercuric chloride) till the surface of the plate is white. The longer the plate is exposed to the action of the mercuric chloride the denser it will become; wash thoroughly and immerse in a bath of 1 minim of strong ammonia to the ounce of water till the plate blackens throughout, then wash and dry. The following is another excellent intensifying bath: After washing whiten the plate in the following: Water, 4 ounces; corrosive sublimate, 10 grains; bromide of potassium, 10 grains; hydrochloric acid, 5 minims. Then wash and blacken in the following: Dissolve 10 grains of cyanide of potassium in 1 ounce of water, to which is then added an ounce of water containing 10 grains of nitrate of silver in solution. After the image is blackened throughout, wash and dry in the air. Corrosive sublimate and cyanide of potassium are violent poisons and must be handled with great care. It is especially important when handling the plates in these solutions that there should be no cuts on the fingers or breaks in the skin, as the cyanide solution will form an ugly ulcerating sore where it comes in contact with abrasions in the skin.

The density of the negative may be reduced by treating the plate with a bath of one part of a saturated solution of ferri cyanide of potassium and ten parts of a ten per cent solution of hyposulphite of soda.

Defects in Negatives.	*Cause.*
Fog.	Over-exposure; white light entering camera or dark room; unsafe developing light; old and decomposed developer; silver nitrate or hyposulphite of soda in developer; developer too warm; too much alkali and not enough bromide in developer.
Weak negatives with clear shadows.	Under development.
Too strong with clear shadows.	Under exposure.
Weak negatives with details well out in shadows.	Over exposure and incorrect development.
Too much density.	Developer too strong or too warm.
Fine transparent lines.	Using too stiff a brush in dusting plates, or slide of plate holder rubs against the surface of the plates or films.
Round transparent spots.	Air bubbles on plate during development.
Pin holes.	Dust.
Yellow stains.	Old developer or washing insufficient to eliminate hypo.
Mottled negatives.	Precipitation from old hyposulphite bath containing alum.
Crystallization on negative.	Imperfect elimination of hypo.
Halation.	Reflection into emulsion by the glass back of the light transmitted through emulsion. May be prevented by coating the back of negative with a black wash, or by using an emulsion of such thickness as to absorb all light falling on it.

CHAPTER III.

Printing and toning—Theory of printing—Preparation of silver baths—Preparation of Paper—Toning baths and methods—Printing on prepared papers—Blue prints—Defects in prints.

Theory of Printing with Preparation of Silver Baths. It has been previously shown how chloride of silver is reduced to a subchloride and darkens when exposed to the action of light. Silver nitrate will combine with albumen, collodion, and gelatin, forming organic salts of silver, which will likewise darken when exposed to the action of light. The paper used in silver printing is usually coated with albumen, collodion, or gelatin containing a chloride and sensitized by floating on a bath of nitrate of silver. The nitrate of silver unites with the chlorine of the chloride forming chloride of silver, and with the albumen, collodion, or gelatin producing an organic salt of silver. The relative amount of the chloride and organic salt depends on the strength of the solution of nitrate of silver, for the organic compound of silver forms much slower than the chloride. Albumen paper usually contains common salt, and it is necessary to know the amount of salt to fix the strength of the silver bath. Albumen paper can be procured from the manufacturers much more cheaply and is more satisfactory than homemade paper, as it is coated by machinery and consequently has a more even coating and better glaze. The manufacturers usually give the necessary strength of the sensitizing bath. If this is not given, a weak bath of about 30 grains of nitrate of silver to the ounce of water is necessary for paper containing but little salt, and a strong bath of about 80 grains for paper containing a large quantity of salt. To determine approximately the amount of salt, cut a quarter sheet of paper (full-sized sheet 18 by 22 inches) into

small pieces and soak in 2 ounces of methylated alcohol, which will dissolve off most of the albumen containing the salt; decant and soak a second time in the same amount of alcohol and add the two portions together. Evaporate the alcohol and dissolve the residue in water; then add a few drops of nitrate of silver, which precipitates the chloride as chloride of silver. Filter, dry, and weigh. If the precipitate weighs about 3 grains, use 30 grains to the ounce for the sensitizing bath; if about 10 grains, use 80 grains to the ounce; between these limits the normal bath should be employed. The normal sensitizing bath is prepared by dissolving 50 grains of nitrate of silver to the ounce of distilled water, and in very dry parts of this country it is advisable to add 50 grains of nitrate of ammonium or sodium to the ounce of the bath; for paper prints better if there is a trace of moisture present, and the nitrate of ammonium and sodium, being deliquescent, will absorb the necessary quantity of moisture from the air. It is absolutely essential that the bath should be alkaline. A bath may be tested for this with litmus paper. If blue litmus paper reddens, carbonate of sodium should be added till the paper ceases to lose its blue color. The addition of carbonate of sodium will produce a slight precipitate of carbonate of silver, which is a good thing, for if there is any free nitric acid in the bath it will attack the carbonate of silver, forming nitrate of silver and setting free carbonic oxide, $Ag_2CO_3 + 2HNO_3 = 2AgNO_3 + H_2O + CO_2$. Each sheet of paper as it is sensitized uses up a certain amount of the nitrate, and the bath should be kept up to the normal strength. The strength of the solution can be tested by an hydrometer that has been previously graduated in a standard bath. The operation of silvering dissolves a small quantity of organic matter, and this in time will discolor the bath. To clear the bath, add 5 or 6 grains of carbonate of sodium and place in the sun. The organic matter is

oxidized at the expense of the silver nitrate, metallic silver and the oxidized organic matter being precipitated, Decant off the clear solution and bring up the normal strength by adding a sufficient quantity of nitrate of silver. In an old bath there will be enough of nitrate of sodium, so that the addition of nitrate of sodium as above suggested will not be necessary. Before and after floating the paper, the bath must always be filtered. For harsh negatives, silver with a bath of 30 grains to the ounce and print in full sunlight; for weak negatives, use an 80-grain bath, and print in the shade.

Sensitizing the Paper. To sensitize the paper, use a flat-bottomed tray about an inch larger in size than the paper. The paper should be grasped at the two diagonally opposite corners, albumen side down, the hands brought together, and the paper gently lowered on the bath. The paper will now touch the bath along the other diagonal of the sheet, lower the hands slowly and allow the paper to gradually settle so that it will float freely on the bath. By this method all the air is forced out from between the paper and the surface of the bath, and there should be no air bubbles. To be sure of this, raise the paper by the unused corners, and if any small bubbles be discovered sticking to the paper, they can be removed by breaking with the edge of a narrow strip of clean blotting paper. Before floating, the surface of the bath should be freed from air bubbles and scum by passing a piece of clean blotting paper over it. The tray must be absolutely clean and used for no other purpose. In winter both the bath and the tray should be warmed till they are about 65 degrees Fahrenheit. The length of floating depends upon the character of the negatives to be printed, and three minutes will suffice for nearly all cases. At the end of this time, carefully raise one corner of the paper with a glass rod, lifting slowly, till another corner is clear of the surface, then raise the sheet very slowly, permitting it to

drain from a corner. Hang up to dry on a line in the dark room from a corner by a clip, taking care that the corner from which the sheet drained is the lowest, stick a small piece of blotting paper on the lower corner to absorb the drainings; when very nearly dry, take the paper down and place between sheets of clean blotting paper under boards to keep it flat for printing. Sensitized paper will keep but for a couple of days, especially in moist, hot weather. Its keeping properties can be improved by passing it rapidly a couple of times through clean water and then drying. Previous to printing, this paper should be fumed in a dark box by exposing it to the fumes of ammonia for about twenty minutes, care being taken that the paper is fumed evenly. Sensitized paper can be kept a couple of months if 20 grains of citric acid be added to each ounce of the bath, but paper prepared in this way should be strongly fumed or else there will be trouble in toning.

Printing. Good printing requires experience and close attention to the smallest details, and a little common sense is quite as necessary as clean manipulation. Before printing it is better to varnish the negative, as this not only prevents danger of scratching but also from staining by the silver on the paper. Printing should be continued until the shadows begin to bronze out well, but it should be remembered, however, that the print loses strength when toning and fixing, and allowance should be made for this. The negative is placed in the printing frame, film side up, covered by a piece of sensitized paper, silver side down, then backed by a piece of blotting paper or felt, the back of the frame locked on, and the frame exposed to the light. It is a good plan to allow the paper, after having been cut, to be exposed to the action of the air (but not the light) for about thirty minutes before printing, so that, when placed in the frame, it will neither expand nor contract in the frame, either from

absorbing moisture from the air or drying out, and blur the image. The paper, during printing, should be examined only in subdued light, as a neglect of this precaution ruins the purity of the whites in the finished print.

Toning. Prints should be kept in a dark box until they are toned, which should be done not later than twenty-four or thirty-six hours after printing. If, after printing, the image should be fixed out, the resulting picture would have a disagreeable reddish color which is obviated by toning before fixing. This is done by the use of chloride of gold, the gold being probably precipitated on the silver, giving an agreeable purplish color. Chloride of gold, as supplied by the dealers, comes in sealed bottles, containing fifteen grains, and is quite deliquescent. It is best to keep the gold in solution by using one grain to the ounce of water.

Toning Formulas. For purple and black tones use 9 ounces of water and 1 of the gold solution neutralized by carbonate of sodium till the bath reacts alkaline. Too much carbonate will produce cold, slaty tones. This bath must be used immediately and will not keep. For purple tones keep prints in bath till they are of a dark brown color, and for black tones, till they are slightly blue.

For a rich, warm tone use 1 once of gold solution, 30 grains of acetate of sodium, and 8 ounces of water. The longer the print is kept in the bath the browner the tone. The bath should be prepared at least twenty-four hours before use, and the longer it stands before using the more satisfactory are the resulting tones. This bath keeps well.

For purple or black use 1 ounce of gold solution, 10 grains of borax, and 10 ounces of water. This bath can be used immediately and does not keep well.

Process of Toning and Fixing Prints.

Previous to being toned, the prints should be trimmed and washed, face downward, until there is no trace of cloudiness in the water, care being taken that they do not stick together. Place the prints face up, one by one, in the toning bath, keeping them separated from each other by a layer of liquid, and give the tray a gentle, rocking motion. When the toning has progressed far enough, remove from the bath and place face downward in water to stop the action of the bath. The addition of a little salt will be found to assist the stopping of the action of the bath and prevents the tendency to blister. The prints should then be transferred to the fixing bath, which is made up of one part of hyposulphite of soda to four of water, and kept in this bath for ten or fifteen minutes. When the prints are fixed, the whites will appear colorless, and the shadows free from red spots. A dram of ammonia to each 10 ounces of the bath may be added with advantage, as the ammonia increases the rapidity of fixing and prevents blistering. The prints are then to be removed from the bath, drained, and washed in running water for at least three hours to eliminate the last trace of hyposulphite of soda, which, if left in the paper, will cause the prints to lose brilliancy and fade. In trimming prints before toning, lay them on a sheet of plate glass and cut with a print trimmer or sharp knife. It is best to have forms of glass or ebonite cut to the proper size to be used as a guide in trimming, and great care should be taken that they are scrupulously clean and that the fingers do not touch the surface of the print while trimming. After the final washing, remove the prints from the water and place in succession face down on a glass plate, one on top of the other. Squeegee off the superfluous moisture, paste the back of each successively with mountant, and transfer to the mount, which should be perfectly free from hyposulphite of soda. After laying on the

mount, smooth down with an old, clean linen rag, then cover the face with a piece of clean blotting paper and run the roller squeegee over two or three times, and stand on edge to dry. While drying, prints should never be laid one on top of the other. When perfectly dry the prints are ready for burnishing, and should have their surfaces lubricated by a little pure castile soap rubbed on with a piece of Canton flannel. The burnisher must be first adjusted to the proper thickness of the mount, then heated up, care being taken that it is not too hot, and cleaned by running a blank mount through three or four times to remove dust from the rollers. Then the prints should be run through in succession till their surfaces acquire the required amount of polish. The burnisher when not in use should be kept carefully covered over to prevent dirt and dust from collecting on the rollers and proving a source of annoyance, as grit will scratch the surface of the prints, especially if the paper is coated with gelatin or collodion. If it is desired to give prints a glacé finish, squeegee while wet on a ferrotype plate which has been previously cleaned with French chalk to remove all traces of dirt and grease. When dry the prints can be readily peeled off, and will be found to possess a smooth, polished surface. If the prints stick the plate is not clean. The following is an excellent mountant for glacé prints: White gelatin 2 ounces, dissolved in 10 ounces of boiling water, to which is then added 5 ounces of alcohol and ½ ounce of glycerin. This paste can be applied to the back of the print with a brush. For mounting use Higgins' mountant or Daisy paste, or a paste prepared by thoroughly boiling flour or starch and using warm.

Captain Abney gives the following maxims:

1. Prints should have the highest lights nearly white, the shadows verging on a bronze color before toning.

2. Print in the shade or direct sunshine, according to the density of the negative.

3. Before toning, place the prints in the water, face downward, and do not wash away too much of the free nitrate of silver.

4. The toning solution must be neutral or slightly alkaline, and not colder than 60°.

5. Tone the prints to purple or sepia according as warm or brown tones are required.

6. Move the prints in both the toning and fixing solutions repeatedly, taking care that no air bubbles form on the surface.

7. Take care that the fixing bath is not acid.

8. Use fresh sodium hyposulphite for each batch of prints to be fixed.

9. Wash thoroughly before and after fixing.

10. Make the sensitizing bath of a strength likely to give the best results with the negatives to be printed ; a weak negative should be printed in a feeble light, and a dense negative in the sunshine.

Use of Ready Sensitized Paper. When using the ready sensitized gelatin or collodion papers, such as aristo, aristo-platino, solio, kloro, ilo, nepera, etc., and platinotype paper, it is best to adhere strictly to the printed directions, which are supplied by the manufacturers. Separate toning and fixing, however, is much preferable to the use of the combined toning and fixing bath, as its action is quite uncertain. It is very difficult to ascertain, with the combined bath, just when the gold toning stops and the sulphur toning begins, and after considerable use there is always an uncertainty as to the amounts of gold and hyposulphite in the bath.

Printing on Plain Paper. It may sometimes happen that neither albumen paper nor prepared paper is at hand and silver prints must be made. These can be made on drawing paper by floating it for three minutes in the following bath.

Ammonium chloride	grains	60 to 80
Citrate of sodium	grains	100
Chloride of sodium	grains	20 to 30
Gelatin	grains	10
Distilled water	ounces	10

or,

Ammonium chloride	grains	100
Gelatin	grains	10
Distilled water	ounces	10

Dissolve the gelatin first in hot water, then add the other constituents. After floating, dry, and then float on the normal silver bath. The subsequent operations are the same as for albumen paper.

Blue Prints. To make blue prints, float drawing paper or any good, close-grained, unsized paper on the following bath: One part of ammonio-citrate of iron to four parts of water, to which is added one part of ferri-cyanide of potassium to four parts of water. This bath must be used immediately, and will not keep when exposed to the action of the light. Instead of floating, the bath may be applied with a sponge by going over the surface twice in directions at right angles to each other; when dry, print in the ordinary way till the surface is well bronzed and develop by placing in water, washing until the water is free from any yellowish tinge; dry, and the operation is complete. This gives white lines on blue background. If the print is too blue, the color may be reduced by a bath of ammonia and water and a subsequent washing and drying.

Black Lines on White Ground. For black lines on white ground, apply the following to the surface of drawing paper:

Water	ounces	9
Gelatin	drams	3
Solution of perchloride of iron (U. S. Ph)	drams	6
Tartaric acid	drams	3
Ferric sulphate	drams	3

After printing, develop in the following solution:

Gallic acid	drams	6
Alcohol	ounces	6½
Water	ounces	32

Then wash thoroughly and dry.

Defects in Prints.	*Cause.*
1. Small white spots with black center,	Dust on paper.
2. Gray starlike spots.	Inorganic matter in paper.
3. Bronze lines, if straight.	Line of stoppage during floating of paper.

Defects in Prints.	*Cause.*
4. Bronze lines, curved.	Scum on sensitizing bath.
5. Marbled appearance of print.	Baths too weak, or not floated enough.

NOTE.—3, 4, and 5 refer especially to albumen paper.

6. Red spots on prints, especially in shadows.	Marks caused by moist fingers coming in contact with paper.
7. Weak prints.	Weak negatives.
8. Harsh prints.	Harsh negatives.
9. Too red a tone.	Undertoning.
10. Cold blue tone.	Overtoning.
11. Streaky prints.	Acid toning bath.
12. Whites appear yellow.	Imperfect washing; imperfect toning; not long enough fixing.
13. Yellow spots when dry.	Imperfect elimination of hypo.
14. Prints refuse tone.	Gold exhausted from toning baths, or there is hypo in separate toning baths.
15. Dark, mottled appearance in body of paper.	Improper fixing in too strong a light.
16. Blisters.	Saline solution between emulsion and paper. Can be prevented by salting the first wash water.

CHAPTER IV.

Cameras and exposure—Description of cameras and roll holder—Methods of use of same—Shutters—Exposure and exposure tables.

Cameras. The ordinary camera consists of a dark box having two square ends, the front one containing a front board on which the lens is mounted by being screwed in a flange, and the rear one is supplied with a piece of ground glass and grooved to receive a plate holder. The two ends are connected by an extension bellows, which should be made of red Russia leather, if the camera is to be used in the field, since

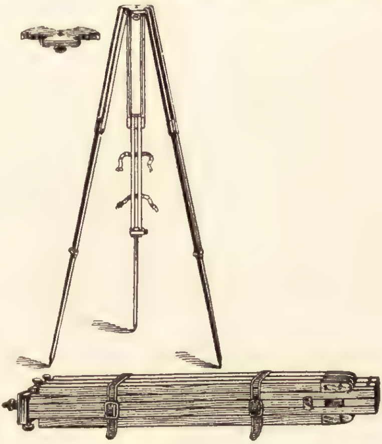


Fig. 11.

red ants will not eat this kind of leather. The camera is usually focused by a rack motion. If the rear end moves, the camera is said to have a back focus; if the lens moves, the camera possesses a front focus. The lens should be capable of being moved up and down on

the front board, and this is sometimes given a motion from side to side called front swing. The rear end usually has a motion about an horizontal axis called a back swing, the back of the camera being the swing back, and sometimes a motion around a vertical axis called a side swing. Cameras are either used on a tripod, which should be light and strong and capable of being packed in a small space, a very convenient tripod being shown in fig. 11, or they are used from the hand, when they are known as hand or detective cameras. The essential requirements of a good camera for military purposes are lightness, compactness, strength, all wood thoroughly seasoned, and all metal parts strong and accurately made.

a

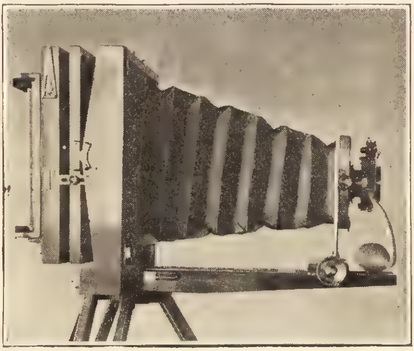


FIG. 12.

Fig. 12 shows a very good revolving back camera. It has a front focus, side and back swing, and rising front board. The revolving back is extremely convenient when working in cramped places, as the plate holder can be inserted and slide removed in a horizontal position, and the plate holder then revolved to any position that may be desired. The camera is supplied

with a plummet (a), fig. 12, to show when the swing back is vertical.

Hand Cameras. Fig. 13 is given to show a type of hand camera. It is a Henry Clay, 5″ by 7″, has a rising front, front focus, front swing, and a space in rear of the ground glass large enough to store three plate holders or insert a roll holder. It can be used also with a tripod, and is supplied with a finder to show the field covered by the lens. Such an attachment is necessary for all cameras, when photographs of objects in action are to be made, or when the camera is used from the hand.

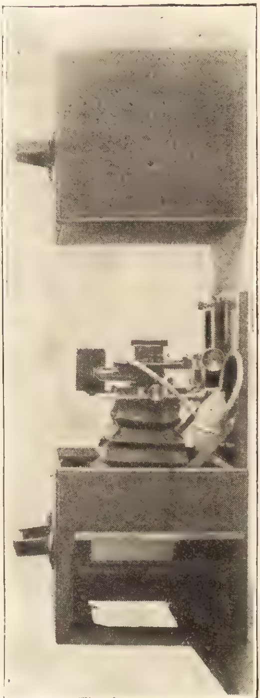


Fig. 13.

Focusing Scale and Cloth. All cameras should have a scale showing the position of the lens for focusing of objects at various distances, and all tripod cameras should have the position of universal focus with some stop number, say $\frac{f}{11}$ or $\frac{f}{16}$, marked on the focusing rack. The focusing cloth should be of rubber or good stout black material, and have a quantity of shot sewed in a hem around the edges, which will prevent its being blown off the

camera when used in high wind. It is well to rule the ground glass of the finder with rectangles, showing the exact size of the field covered by the camera at different distances. This will prevent the annoyance of dis covering, after development, that parts of the object exposed for are not on the plate, and is especially valuable in ascertaining the position on the plate of rapidly moving objects. The ground glass of the camera should have the center marked by the intersection of its two diagonals and should have two lines drawn through this center, one parallel to the top and the other parallel to the side of the ground-glass frame.

Roll Holder. A roll holder is a device by which a large number of exposures may be taken without removing it from the camera. It consists of a box with a movable slide like a plate holder. The box contains two rollers, one of which has a handle projecting on the outside by which it can be turned and winds up the sensitive film, which has been previously coiled on the other roller (see fig. 14). It is provided with a click, which indicates just when the proper amount of film has been unwound, and with an ingenious arrangement of cutting points which makes cuts near the top and bottom edges of the continuous film, indicating the boundaries of each exposure on the roll of film.

Levels. In use, the normal position of the camera is level, and the *swing back should always be vertical.* A level such as shown in fig. 15 is the best means of finding out if the camera is horizontal; if the camera is supplied with a plummet, as in fig. 12, this will indicate the same fact. If neither of these means is at hand, suspend a stone or a bunch of keys by a string to get a vertical line and bring the side of the swing back parallel to this, and the camera will be level, for the swing back is always constructed

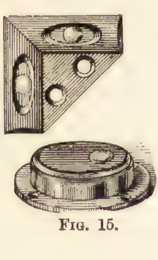


FIG. 15.

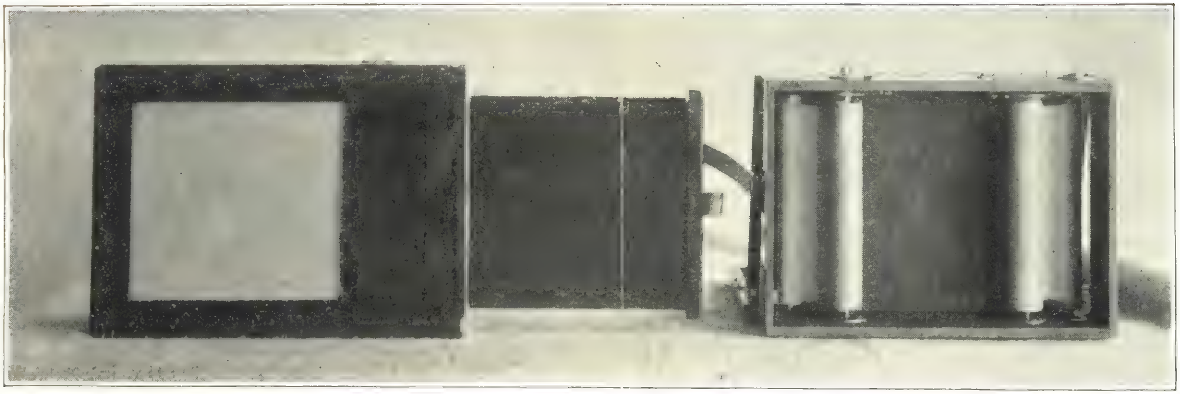


Fig. 14.

in the form of a perfect square. It may happen that the image is too high or too low on the ground glass and

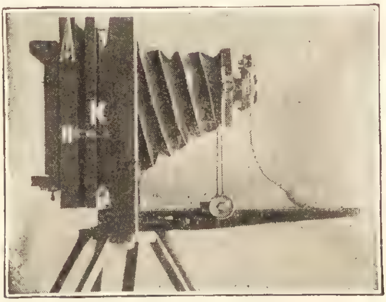


Fig. 16.

its position can be changed by the use of the rising front board, as is shown in fig. 16.

Front Board and Swing Back. Sometimes the correct position of the image can not be obtained by the use of the front board alone, when it is necessary to incline the camera bed, when the *swing back must be vertical* as in fig. 17.

Fig. 17.

Shutters. The lenses which are supplied with hand cameras usually have some kind of shutter which will make both time and instantaneous exposures. It is advisable that the lenses on tripod cameras should also have this kind of shutter, which

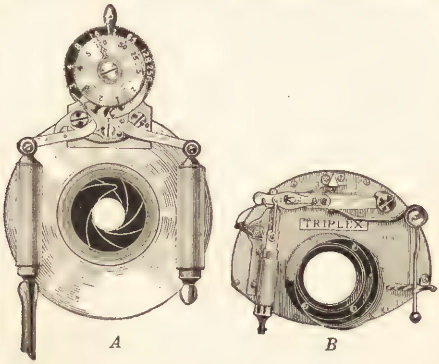
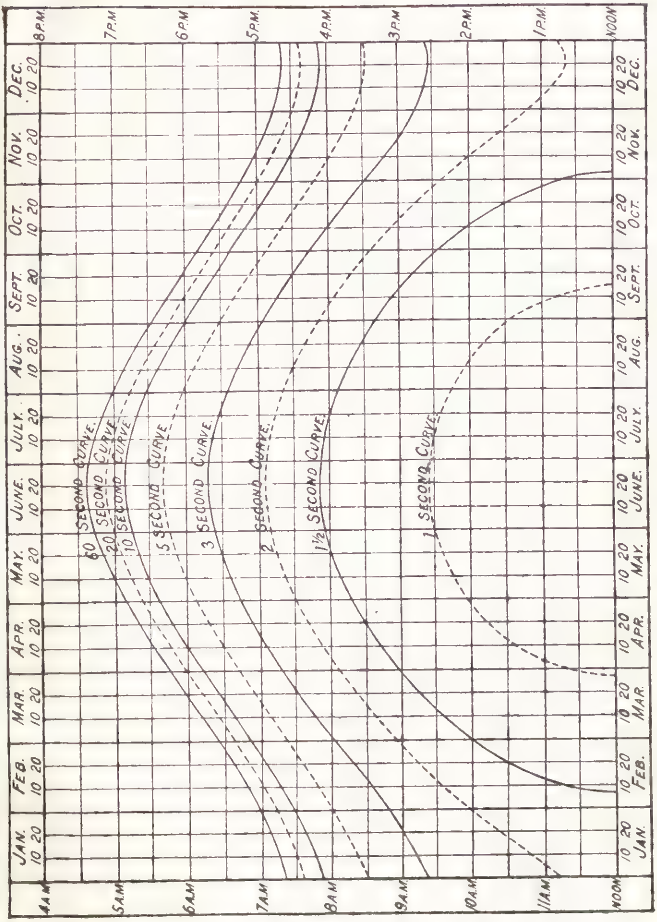


FIG. 18.

is usually operated by a cylinder whose piston is actuated by compressed air, supplied by squeezing a bulb, and controlling the opening and closing mechanism of the shutter. An example of two of the many good shutters on the market is given in fig. 18, A being a pneumatic shutter and B a triplex pneumatic.

Exposure Tables. The correct timing of exposures is perhaps the most difficult of all photographic operations for beginners, and by experience alone can this knowledge be acquired. A few suggestions, however, will be of assistance. The photographic intensity of daylight varies with the hour of the day and the time of the year. The following diagram which was calculated by Lieut. Commander S. W. Very, U. S. Navy, for the latitude of Washington shows the relative time of exposure for the various hours of the day and the months of the year:


60 SECOND CURVE
20 SECOND CURVE
10 SECOND CURVE
5 SECOND CURVE
3 SECOND CURVE
2 SECOND CURVE
1½ SECOND CURVE
1 SECOND CURVE
JAN. FEB. MAR. APR. MAY. JUNE. JULY. AUG. SEPT. OCT. NOV. DEC.
10 20
4 A.M. 5 A.M. 6 A.M. 7 A.M. 8 A.M. 9 A.M. 10 A.M. 11 A.M. NOON
8 P.M. 7 P.M. 6 P.M. 5 P.M. 4 P.M. 3 P.M. 2 P.M. 1 P.M. NOON

It is correct for apparent local time and can be used without sensible error anywhere between latitudes 30 and 50 north. To show how to use the diagram, let us take an example. It is found that at 2.30 p. m. on July 10 with a certain lens a two-second exposure on an object was necessary, and it is desired to know the length of an exposure, with the same lens on the same object at 5 p. m. on the 20th of October. Look along the 2.30 p. m. horizontal line till the vertical line headed July 10 is met. The intersection of these two is found on the one second curve; 5 p. m. on the 20th of October is found on the ten-second curve and the exposure is ten times as long and should be twenty seconds.

Lengths of Exposure.

To show the relative length of exposures on different subjects Table A has been adopted from Burton's table. The table shows the relative length of exposures on different objects, taking the exposure on an open landscape in clear weather with an $\frac{f}{16}$ stop as unity. It is supposed that this exposure has been previously determined by experiment and the following examples will show the use of the table. It is known that with a Carbutt B 16 plate and with $\frac{f}{16}$ stop the normal exposure on an open landscape on a certain day was three seconds, and it is desired to know how long an exposure is necessary on the same day with $\frac{f}{8}$ on a badly lighted interior. In Table A, look at the column headed "stop number" and find $\frac{f}{8}$, then follow the horizontal line until the column headed "badly lighted interiors" is reached, where the number 1,440 will be found. The exposure is then 1,440 times three seconds or 1 hour and 28½ minutes. The normal exposure on an open land-

scape with a Carbutt Eclipse 27 was found to be one-quarter of a second, and it is required to know the proper exposure with $\frac{f}{64}$ on a landscape with foliage in the foreground. The table gives a factor 96, and the exposure should be 96 by ¼ second, or 24 seconds. The combination of this table with the preceding diagram

TABLE A.

Stop number.	Open landscape.	Landscape with heavy foliage in foreground.	Under trees up to.	Fairly lighted interiors.	Badly lighted interiors.
$\frac{f}{8}$	0.25	1.50	150	150	1,440
$\frac{f}{11}$	0.50	3.00	300	300	2,880
$\frac{f}{16}$	1.00	6.00	600	600	5,760
$\frac{f}{32}$	4.00	24.00	2,400	2,400	23,040
$\frac{f}{64}$	16.00	96.00	9,600	9,600	92,160

will show the necessary length of exposure on all subjects from which photographs are made for military purposes, and it is only necessary to determine the proper exposure on any kind of plates on a bright, clear day with $\frac{f}{16}$ on an open landscape, and using this as a basis all other exposures can be calculated. The amount of moisture, fog, smoke, or dust in the air greatly affects the actinic value of the light, and the beginner is very frequently surprised at the result obtained when using the calculated time of exposure as given in the above tables. These are given as a guide simply, and experience is absolutely necessary to judge the relative rapidity of light. A notebook should always be kept, and for each exposure the following data should be

entered: Kind of lens, number of stop, length of exposure, make and sensitometer number of plate, date, hour, and subject. The data thus recorded will assist in judging the correct time of exposure on similar objects under similar circumstances.

CHAPTER V.

Photographic Chemicals.

The following is a brief description of the principal chemicals mentioned in the text:

Acetic acid, pyroligneous acid, or, in a diluted form, vinegar, symbol, $C_2H_4O_2$. The pure acid is a colorless fuming liquid, which boils at 245° F. The ordinary acetic acid used in photography is known as glacial acetic acid, has a pleasant characteristic odor, and specific gravity at 59° F., 1.063. The ordinary glacial acetic acid supplied by dealers has a specific gravity of about 1.044 and contains about 33 per cent of pure glacial acid.

Citric acid, $C_6H_6O_7$, occurs in white transparent crystals, dissolves in half of its weight of hot water and three-quarters of its weight of cold water, and its own weight of alcohol. The usual impurity is tartaric acid, which may be detected by adding a strong solution of potassium acetate, when a white precipitate will be formed if tartaric acid is present.

Gallic acid, $C_7H_6O_5$, occurs in small fawn-colored crystals, soluble in three times its weight of hot water and twenty times its weight in cold water.

Hydrochloric acid, muriatic acid, or spirits of salts, HCl, when pure, is a nearly colorless fuming liquid, whose specific gravity depends on the degree of concentration; usual impurities, sulphuric acid, iron, and arsenic. Sulphuric acid may be detected by a solution of chloride of barium, which will give a white precipitate of barium sulphate if sulphuric acid is present.

Nitric acid, or aqua fortis, HNO_3, is, when pure, a colorless, highly corrosive, fuming liquid, whose specific gravity depends on the degree of concentration.

The usual commercial acid at 59° F. has a specific gravity of 1.29 and contains 46 per cent of pure acid. The usual impurity is a trace of sulphuric acid, which may be detected by barium chloride.

Oxalic acid, $H_2C_2O_4$, $2H_2O$, occurs in transparent needle-shaped crystals, is readily soluble in water, insoluble in alcohol, quite poisonous, and may contain a trace of sulphuric acid.

Pyrogallic acid or pyro, $C_6H_6O_3$, occurs in fine light needle-shaped crystals bunched together, is readily soluble in water or alcohol, and when in solution or exposed to moist air absorbs oxygen and is decomposed. It is poisonous.

Sulphuric acid or oil of vitriol, H_2SO_4, is a heavy oily liquid with a slight grayish color, very corrosive, and has a great affinity for water. Its specific gravity depends on the degree of concentration, and the specific gravity of 1.842 at 59 degrees F. represents 100 per cent acid. It may contain salts of lead, potassium, or sodium, which may be discovered as a residue, when the acid is evaporated to dryness.

Albumen, a substance of very indefinite composition, occurs in the white of egg and the serum of the blood, is freely soluble in cold water and in strong nitric acid and acetic acid. The aqueous solution is coagulated by heat.

Alcohol (ethyl) or spirits of wine, C_2H_6O. Anhydrous alcohol is a colorless liquid with a characteristic odor and burning taste; its specific gravity at 59° F. is 0.794; burns with a smokeless flame. In commerce it is found in various degrees of dilution, and is rated at so many degrees above or below proof, which is an alcohol of 0.92 specific gravity at 59° F. It mixes readily with water and ether, and is a good solvent for gums and resins.

Alum or potash alum, $Al_2K_2(SO_4)_4$, $12H_2O$, occurs in transparent irregular crystals or as a white powder;

when anhydrous (that is, without water of crystallization) is soluble in eight parts of hot water and ten parts of cold; insoluble in alcohol.

Alum chrome, $KCr(SO_4)_2$, $12H_2O$, occurs in dark violet permanent crystals; is soluble in seven parts of cold water, which gives a blue solution, and, when dissolved in hot water, a green solution, from which it can not be crystallized.

Ammonia or hartshorn, NH_4O, is a strong, pungent, colorless, volatile liquid, mixes readily with water and alcohol, and the solution will dissolve shellac and resin. Strong ammonia is a solvent for chloride and bromide of silver.

Chloride of ammonia, muriate of ammonia, or sal ammoniac, NH_4Cl, occurs in commercial form in tough translucent fibrous masses; is soluble in three times its weight of cold water and one and one-quarter of hot water and sparingly so in alcohol.

Ammonium carbonate, sal volatile, or smelling salts, $(NH_4)_2CO_3$, occurs in translucent fibrous masses, smelling strongly of ammonia, soluble in three parts of cold water and sparingly so in alcohol.

Benzol or benzine, C_6H_6, a colorless, volatile liquid, with an odor like coal gas, does not mix with water, but will mix with alcohol and ether and is a good solvent for wax and gums.

Collodion is a solution of gun cotton in a mixture of alcohol and ether.

Eiconogen, $C_{10}H_5NH_2ONaHSO_32H_2O$, occurs in yellowish-white crystals; is sparingly soluble in water and insoluble in alcohol. When in solution or exposed to moist air it will absorb oxygen and break down. It is not poisonous like pyro.

Gelatin is a compound containing carbon, hydrogen, oxygen, nitrogen, and sulphur, and is usually obtained from bones and hides. It occurs in translucent sheets or shreds, and contains from five to twenty per cent of

moisture; placed in water at about 59° F. it swells to five or six times its volume and dissolves when heated to about 110° F. It is soluble in cold oxalic, acetic, hydrochloric, and sulphuric acids.

Gold chloride, $AuCl_3 2H_2O$, occurs in reddish-brown semicrystalline masses and is extremely deliquescent, that is, absorbs moisture very readily from the air.

Ammonio-citrate of iron, $Fe_2(C_6H_5O_7)_3(NH_4)_2$, occurs in thin transparent brownish crystals, slightly deliquescent, and readily soluble in both hot and cold water.

Citrate of iron, $Fe_2(C_6H_5O_7)$, occurs in thin reddish transparent crystals and is extremely soluble in water.

Ferrous oxalate, FeC_2O_4, is a pale-yellow powder, insoluble in water, but soluble in a solution of potassium oxalate.

Ferric oxalate, $Fe_2(C_2O_4)_3$, is a yellowish-brown powder, very slightly soluble in water, but freely so in solution of oxalate of potassium.

Ferrous sulphate, green vitriol, or copperas, $FeSO_4$, occurs in green crystals, which rapidly oxidize when exposed to moist air; is soluble in half its weight of hot and one and a half times its weight of cold water; insoluble in alcohol.

Mercurous chloride or calomel, HgCl, is a white powder, insoluble in water and alcohol.

Mercuric chloride, bichloride of mercury, or corrosive sublimate, $HgCl_2$, occurs in fine white needle-shaped crystals, soluble in three parts of hot and sixteen parts of cold water and five of alcohol; is poisonous.

Potassium bromide, KBr, occurs in white cubical crystals, soluble in one and one-half parts of cold water and insoluble in alcohol.

Potassium chloro-platinite, K_2PtCl_4, occurs in reddish, deliquescent crystals; is freely soluble in water and nearly insoluble in alcohol.

Caustic potash or potassium hydroxide, KHO, occurs in fused sticks or lumps, is quite deliquescent, and will

absorb carbon dioxide from the air; must be kept in well-stoppered bottles; is freely soluble in water and alcohol.

Potassium carbonate or pearlash, $K_2CO_33H_2O$, occurs in a white slightly deliquescent powder, very soluble in water but insoluble in alcohol.

Potassium cyanide, KCn, in commercial form occurs in white opaque lumps, which are deliquescent and will decompose by absorbing carbon dioxide from the air; freely soluble in water, and very slightly so in alcohol. It is intensely poisonous.

Potassium ferricyanide, $K_6Fe_2(CN)_{12}$, occurs in small red crystals, which are freely soluble in water, and, when the solution is exposed to the action of light and air, the ferricyanide is slowly changed to ferrocyanide and a precipitate formed.

Potassium oxalate, $K_2C_2O_4, H_2O$, occurs in confused white crystalline masses or as a white powder; is soluble in two parts of hot and three parts of cold water.

Mastic is a resinous substance, freely soluble in alcohol, ether, benzol, and chloroform.

Silver bromide, AgBr, occurs usually as a yellowish precipitate affected by the light; is insoluble in water, but soluble in strong ammonia, cyanide of potassium, and hyposulphite of sodium.

Silver chloride, AgCl, is a white substance, affected by the light, very slightly soluble in water, but freely so in strong ammonia, cyanide of potassiun, and hyposulphite of sodium.

Iodide of silver, AgI, is a yellowish-white substance, affected by the light; soluble in cyanide of potassium and hyposulphite of sodium.

Silver nitrate or lunar caustic, $AgNO_3$, occurs in colorless tabular crystals and in translucent sticks; is soluble in its own weight of water, and is sometimes contaminated with nitrate of potassium, which will give a characteristic blue color to a flame.

Sandrac is a semitransparent, brittle resin, from one of the varieties of the pine-tree family; is freely soluble in either alcohol or benzol.

Sodium acetate, $NaH_3C_2O_3$, occurs in small transparent crystals; is soluble in three parts of cold and two-thirds of a part, by weight, of hot water; not soluble in alcohol.

Sodium carbonate or sal soda, Na_2CO_3, occurs in crystals and is a coarse granulated powder; is freely soluble in water; in the granular form of the carbonate, can be distinguished from bicarbonate, which always exists as a smooth floury powder.

Caustic soda, or sodium hydroxide, NaHO, is similar in appearance to potassium hydroxide; deliquescent; absorbs carbon dioxide from the air; must be kept in a tightly-stoppered bottle; quite soluble in water and alcohol.

Sodium chloride or common salt, NaCl, occurs in cubical crystals; soluble in three parts of hot and cold water.

Sodium hyposulphite, hypo, or thio-sulphate of sodium, $Na_2S_2O_3$, $5H_2O$, occurs in irregular semitransparent crystalline masses; is extremely soluble in water. Traces of hyposulphite may be detected by adding a drop of the solution of permanganate of potassium to the suspected solution, when the pink color will be destroyed if hypo is present.

Sodium sulphite, Na_2SO_3, $7H_2O$, occurs in crystals, which lose their water of crystallization and oxidize quite easily; is soluble in four parts of cold water and one-half a part of hot water.

Elsden's Table of Poisons and Antidotes.

Poisons.	Remarks.	Characteristic Symptoms.	Antidote.
Vegetable Acids:			
Oxalic Acid, including Potassium Oxalate.	1 dram is the smallest fatal dose known.	Hot, burning sensation in throat and stomach; vomiting, cramps, and numbness.	Chalk, whiting, or magnesia, suspended in water. Plaster or mortar can be used in emergency.
Caustic Alkalies:			
Ammonia, Potash, and Soda.	Vapor of ammonia may cause inflammation of the lungs.	Swelling of tongue, mouth, and fauces; often followed by stricture of the œsophagus.	Vinegar and water.
Metallic Salts:			
Mercuric Chloride.	3 grains the smallest known fatal dose.	Acrid, metallic taste, constriction and burning in throat and stomach, followed by nausea and vomiting.	White and yolk of raw eggs with milk. In emergency, flour paste may be used.
Acetate of Lead.	The subacetate is still more poisonous.	Constriction in the throat and at pit of stomach; crampy pains and stiffness of abdomen; blue line round the gums.	Sulphates of soda or magnesia. Emetic of sulphate of zinc.
Cyanide of Potassium.	*a.* Taken internally, 3 grains fatal.	Insensibility, slow, gasping respiration, dilated pupils, and spasmodic closure of the jaws.	No certain remedy; cold affusion over the head and neck most efficacious.
	b. Applied to wounds and abrasures of the skin.	Smarting sensation.	Sulphate of iron should be applied immediately.
Bichromate of Potassium.	*a.* Taken internally.	Irritant pain in stomach, and vomiting.	Emetics and magnesia, or chalk.
	b. Applied to slight abrasions of the skin.	Produces troublesome sores and ulcers.	
Nitrate of Silver.		Powerful irritant.	Common salt to be given immediately, followed by emetics.
Concentrated Mineral Acids:			
Nitric Acid.	2 drams have been fatal. Inhalation of the fumes has also been fatal.	Corrosion of windpipe and violent inflammation.	Bicarbonate of soda, or carbonate of magnesia or chalk, plaster of the apartment beaten up in water.
Hydrochloric Acid.	½ ounce has caused death.		
Sulphuric Acid.	1 dram has been fatal.		
Acetic Acid, concentrated, has as powerful an effect as the mineral acids.			
Iodine.	Variable in its action; 3 grains have been fatal.	Acrid taste, tightness about the throat, vomiting.	Vomiting should be encouraged, and gruel, arrowroot, and starch given freely.
Ether.	When inhaled.	Effects similar to chloroform.	Cold affusion and artificial respiration.
Pyrogallol.	2 grains sufficient to kill a dog.	Resemble phosphorus poisoning.	No certain remedy. Speedy emetic desirable.

The quantities given in the formulas of Chapters II and III are based on the United States standard Troy grain and fluid ounce:

TROY WEIGHT.

Pound.	Ounce.	Dram.	Grain.
1	12	96	5,760
	1	8	480
		1	60

FLUID MEASURE.

Pound.	Ounce.	Dram.	Minim.
1	16	128	1,760
	1	8	480
		1	60

A fluid pound is the same as a pint. The United States gallon contains 231 cubic inches and the pint or fluid pound 28.875 cubic inches.

CHAPTER VI.

Enlarging, reducing, and copying—Theory—Table of enlargement and reduction—Enlarging and reducing cameras—Preparation of plans, maps, etc., for copying—Enlargement and reduction without the use of a camera.

Theory. In enlarging, reducing, and copying it is necessary to know the distance of the image and object from the lens, and the optical center can be taken without sensible error at the mechanical center of the combination. The sizes of the image and object are directly proportional to their distances from the optical center, and these are given by the equation:

$$\frac{1}{i} = \frac{1}{f} - \frac{1}{o};$$

in which f is the focal length, i and o the distances of the image and the object respectively from the optical center of the combination. The focal length f may be determined by the method given in Chapter I. Let the image required be n times the size of the object, and n, in the case of enlargement, will be greater than unity, and, in the case of reduction, less than unity. Solve the equation for o and i, and the following values will be obtained:

$$o = \frac{if}{i-f} \text{ and } i = \frac{of}{o-f}.$$

In these two equations let us replace i and o by the values $i = no$, and $o = \frac{i}{n}$, when we will obtain the following results:

$$o = f + \frac{f}{n} \text{ and } i = (n+1)f,$$

which gives the distances of the image and object from the lens in terms of the focal length of the lens used, and the number of times of enlargement required. Table B is calculated by these formulas for lenses from 5 to 12 inches in focal length and from one to eight times for enlargement and reduction.

Table B.

Focal length, inches.	Enlargement.	Enlargement or reduction.								Reduction.
		1	2	3	4	5	6	7	8	
5	*o*	10	7.5	6.7	6.2	6.0	5.8	5.7	5.6	*i*
	i	10	15	20	25	30	35	40	45	*o*
5½	*o*	11	8.7	7.5	7.1	6.4	6.3	6.2	6.1	*i*
	i	11	16.5	22	27.5	33	38.5	44	49.5	*o*
6	*o*	12	9	8	7.5	7.2	7	6.9	6.8	*i*
	i	12	18	24	30	36	42	48	54	*o*
6½	*o*	13	9.7	8.6	8.1	7.8	7.6	7.4	7.3	*i*
	i	13	19.5	26	32.5	39	45.5	52	58.5	*o*
7	*o*	14	10.5	9.3	8.8	8.4	8.2	8	7.9	*i*
	i	14	21	28	35	42	49	56	63	*o*
7½	*o*	15	11.2	10	9.4	9	8.7	8.5	8.4	*i*
	i	15	22.5	30	37.5	45	52.5	60	67.5	*o*
8	*o*	16	12	10.7	10	9.6	9.3	9.1	9	*i*
	i	16	24	32	40	48	56	64	72	*o*
8½	*o*	17	12.7	11.3	10.6	10.2	9.9	9.7	9.6	*i*
	i	17	25.5	34	42.5	51	59.5	68	76.5	*o*
9	*o*	18	13.5	12	11.3	10.8	10.5	10.3	10.1	*i*
	i	18	27	36	45	54	63	72	81	*o*
9½	*o*	19	14.2	12.6	11.9	11.4	11.1	10.8	10.7	*i*
	i	19	28.5	38	47.5	57	66.5	76	85.5	*o*
10	*o*	20	15	13.3	12.5	12	11.7	11.4	11.3	*i*
	i	20	30	40	50	60	70	80	90	*o*
10½	*o*	21	15.6	14	13.1	12.6	12.4	12.3	12.2	*i*
	i	21	31.5	42	52.5	63	73.5	84	94.5	*o*
11	*o*	22	16.5	14.7	13.8	13.2	12.8	12.6	12.4	*i*
	i	22	33	44	55	66	77	88	99	*o*
11½	*o*	23	17.2	15.3	14.2	13.8	13.4	13.1	12.9	*i*
	i	23	34.5	46	57.5	69	80.5	92	103.5	*o*
12	*o*	24	18	16	15	14.4	14	13.7	13.5	*i*
	i	24	36	48	60	72	84	96	108	*o*

Enlarging Cameras. The ordinary camera will usually serve for purposes of reduction, but its bellows are not of sufficient length to permit enlargement to any considerable degree. A most convenient camera

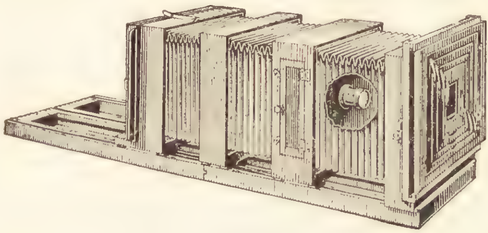


FIG. 19.

for enlarging and reducing is shown in fig. 19. The lens used for work of this character must be of the rectilinear type or else the resultant copy will be distorted.

Preparation of Objects and Procedure. If plans and maps are to be prepared for copying they should be drawn on white paper or on paper with a slightly bluish tint with very black lines. Good stick india ink should be employed, and it is well to add a little coloring matter, such as crimson lake, burnt sienna, or bichromate of potash, which will cause the lines to take white on the negative. In case a considerable reduction in size is desired, it is well to generalize the details. The lettering should be made larger than the original scale of the map would require, and the scale of the map, after reduction, should be drawn on the original. In case of existing plans and maps that have been shaded a flat tint, or if the paper has been yellowed through age, they should be copied in direct sunlight. In all cases the object must be uniformly illuminated by a light coming from a horizontal direction, as the texture of the paper will then be hidden. At night

copies can be made by the light of the electric arc, lime light, magnesium wire, or even the light of a kerosene lamp. It is best to use slow plates as they give denser images. Negatives of line drawings should not be fully developed and should be slightly underexposed. The development should be stopped when the white parts of the negative have been reduced, when they should be washed, fixed, and intensified. This will prevent any deposit on the lines. Excellent black and white results may be obtained by adding to each 4 ounces of the developer 1 ounce of the following solution: Water, 26 ounces; bromide of potassium, 60 grains, to which has been previously added 4 grains of iodine dissolved in $1\frac{3}{4}$ ounces of alcohol.

Copying Objects in Colors. In copying objects in colors, such as oil paintings, lithographs, or water-color sketches, the light should fall on the picture in the same direction as it is supposed to be lighted, which may be judged from the direction of the shadows. Orthochromatic plates and a color screen must be used to get the best results. For all copying work the camera must be horizontal and the object vertical; in the case of maps, etc., these can be stretched on a drawing board and the board placed in a vertical position on a stand or table.

Positives and Enlarging Without a Camera. In enlarging or reducing from negatives positives can be made on glass or bromide paper, and the latter is especially valuable for enlarging from negatives from maps, works, and those made from a captive balloon. To reduce messages for transportation by a carrier pigeon, make negatives on stripping plates, develop and strip the film, which can then be packed in the ordinary way and fastened to the pigeon. To enlarge from this film, first unroll and soften in water, spread on a transparent sheet of glass and fasten in place by flowing the sheet with collodion. The negative can then be used in the enlarging camera

or the ordinary magic lantern. In case no enlarging camera is at hand and it is desired to make enlargements, a room which has been previously made light-tight can be used by placing the lens in an opening in one of the windows, care being taken that no light leaks around the front board, fitting a track on the window sill to support a light frame to hold the negative, and by stretching bromide paper on a vertical easel, which should be arranged to run on a track on the floor.

CHAPTER VII.

PHOTOGRAPHIC TOPOGRAPHY—PHOTOGRAPHIC PERSPECTIVE AND PRINCIPLES—DETERMINATION OF AZIMUTH AND ANGLE OF ELEVATION—PREPARATION OF CAMERA FOR FIELD WORK—SELECTION OF STATIONS—DETAILS OF FIELD WORK, ETC.—SOLUTION OF THE GENERAL CASE WITH THE CAMERA IN ANY POSITION.

Photographic Perspective and Principles of Methods.

Photography is of great assistance in all kinds of topographical works, especially so in reconnoissance, and will give results which are much more quickly and accurately obtained than by methods used in ordinary military reconnoissance. With proper instruments the photographic method can be applied to topographical surveys with extremely accurate results and produce a great saving of time in field work while the photographs themselves serve as a permanent record which is much fuller and better than any field notebook can give. In any method of surveying the location of points is given by their distances, azimuth, and elevation from some fixed point of reference previously determined. Points are constructed on a map by laying down their distances from the reference point on the azimuth line, or they are located by the intersection of azimuths from two or more known points. Their elevations are obtained from their horizontal distance and angle of elevation or depression. The photographic negative will give azimuths and angles of elevation, for it will be observed in fig. 20 that a ray, EO, from the point *e* of the object will make the same relative horizontal and vertical angles with the optical axis, after passing the optical center as before, but will be on the opposite side of the horizontal and vertical plane passing through the optical axis. This ray will intersect the negative at the point *e* and give the image of the point of the object on

the sensitive film. If the camera is perfectly level, HL will be the trace of the horizontal plane containing the optical axis and is called the horizon of the picture.

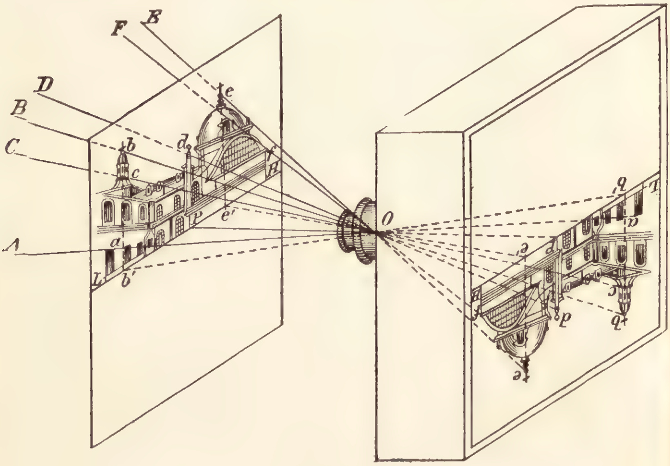


FIG. 20.

The trace of the vertical plane containing the optical axis on the picture is called the middle vertical. The azimuth of any point with respect to the optical axis is the horizontal angle between two vertical planes, one containing the optical axis and the other the ray which passes from any point of the object through the optical center of the combination. The vertical angle or angle of elevation is the angle in the vertical plane containing the ray between the ray and its projection on the plane of the horizon. In fig. 21, let A B D C be the plane of the sensitive film which is supposed to be vertical, O the optical center of the lens, OP the optical axis, and P the point where the optical axis intersects the plane of the picture. This point is called the principal point.

The plane MVKG is the vertical plane through the optical axis and HLFE the horizontal plane containing the optical axis or the plane of the horizon, and QRST the vertical plane containing the ray XX′ which passes

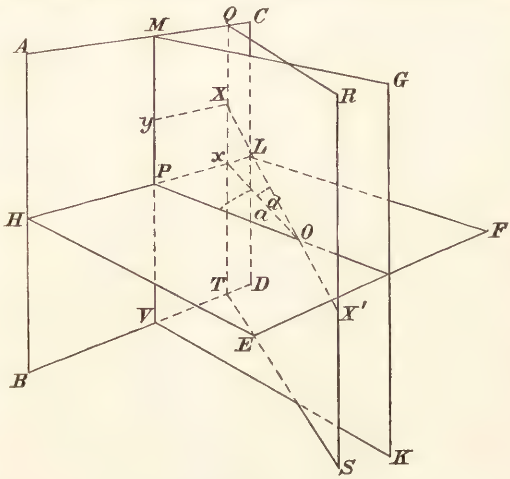


FIG. 21.

through the optical center. The point X is the image on the negative, x is the projection of the point X on the horizon, and y its projection on the middle vertical. Px and Py are the coordinates of the image X with respect to the horizon and middle vertical as coordinate axes and we will call them the horizontal and vertical distances. The angle xOP is the azimuth angle or angle a. The angle xOX is the vertical angle or angle of elevation which we will call d. The distance OP is of course the focal length of the lens used and the azimuth angle is given by the expression,

$$\tan x\text{OP or } \tan a = \frac{x\text{P}}{\text{OP}} \text{ or } \frac{\text{horizontal distance}}{\text{focal length}}$$

The angle of elevation is given by the expression, $\tan xOX$ or $\tan d = \frac{Xx}{xO}$, but xX is the vertical distance and xO is equal to the horizontal distance divided by the sine of the azimuth angle. Substitute these values in the expression for the tangent of the angle of elevation and we have,

$$\tan d = \frac{\text{vertical distance}}{\text{horizontal distance}} \cdot \text{sine } a.$$

This latter formula will fail when the image is on the middle vertical, as the azimuth angle will then be zero, and in this case the tangent of the angle of elevation will be equal to the vertical distance divided by the focal length. These expressions give us at once the rules for finding the azimuth angle and angle of elevation. First project the point on the horizon and middle vertical and measure the horizontal and vertical distances; divide the horizontal distance by the focal length and this will give the natural tangent of the azimuth angle, which can be taken from a table of natural tangents. If the image is not on the middle vertical, multiply the quotient of the vertical by the horizontal distance by the natural sine of the azimuth angle and this gives the natural tangent of the angle of elevation. If on the middle vertical, the quotient of the vertical distance by the focal length is the natural tangent of the angle of elevation. The calculation of these angles is greatly facilitated by the use of a slide rule, which has the focal length of the lens marked on it for rapidity of setting. If no table of sines and tangents is at hand, the azimuth may be constructed by drawing two lines at right angles to each other equal in length to the horizontal distance and focal length and joining their extremities. The angle which the last line makes with the line representing the focal length will give the required azimuth. If a line is now drawn perpendicular to the last line, and its length be made equal to the

vertical distance and its extremity joined by a line to the vertex of the preceding triangle, the angle between the hypothenuses of the two triangles is the required vertical angle. For example, it is required to construct the azimuth angle and the angle of elevation of a certain point on the negative made with an 8-inch equivalent focus lens, the horizontal distance being 2 inches

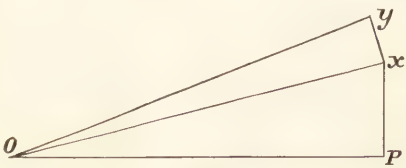


FIG. 22.

and the vertical distance 1 inch. In fig. 22 draw OP to scale 8 inches long, at P erect a perpendicular Px 2 inches in length, draw Ox, and the angle xOP is the required azimuth. Draw xy perpendicular to Ox 1 inch in length, join O and y, and the angle xOy is the required vertical angle.

Preparation of Camera for Topographic Work.

The lens used for topographical work must be rectilinear, and the wider the angle the better, as a fewer number of plates will be required to cover a given angular space. Such a camera as shown in fig. 12 is admirably adapted for making topographical negatives, and should be provided with an attached level of the type shown in fig. 15, and should possess also, if possible, an attached compass whose 0–180° line is parallel to the optical axis. This compass will then give the magnetic bearing of the optical axis. The ground glass should have the horizon, middle vertical, and principal point marked on it. The center of the ground glass or principal point is obtained by the intersection of the diagonals of the ground-glass frame. The horizon is then drawn through the principal point

by setting the camera up vertically and laying a carpenter's level against the ground-glass frame, the top edge of the level passing through the center of the ground glass and a horizontal line drawn through the given point. The middle vertical is then drawn through the principal point perpendicular to the horizontal line. The optical axis must now be brought into the horizon, and this is done in the following manner: Measure accurately the height of the horizontal line on the ground glass from the ground; set the lens at universal focus; place in front of the camera, at some considerable distance away on level ground, a vertical rod with a target at the same height from the ground as the horizontal line on the ground glass and move the lens in the rising front till the image of the target coincides with the horizontal line on the ground glass. This position of the lens should then be marked on the rising front. It is well to graduate the rising front, so that if it is necessary to raise or lower the lens from its normal position, the displacement of the horizon from the middle of the picture can be determined by reference to the scale. The plate holder should be so arranged that when the exposure is made the horizon and middle vertical will be marked on the plates. There are a variety of ways of doing this; one of the simplest is to insert on the inside edge of the plate holder, at the proper points, short pieces of hardened steel needles, so as to project about one-quarter of an inch from the edge of the plate holder. When the plates are developed, the part covered by these projections will appear as clear glass, and serve as a guide to draw the horizon and middle vertical.

Selection of Stations; Field Work.

In selecting stations the photographs should include as much as possible of the topographical features of the country to be mapped and commanding points should of course be occupied. Experience has shown

that the best arrangement of stations is in groups of three, the stations being mutually intervisible. If there is no natural mark to identify the station, an artificial one of some kind should be constructed, such as a flag, a post with cross arms, a large pile of stones, etc. If points have been located by previous triangulation, it is only necessary to occupy these stations in succession, selecting such time of day as to have the sun behind the camera if possible. In setting up for an exposure place the camera over the station and level approximately, set the lens to the universal focus, insert the plate holder, then make the camera perfectly level, expose, and read the attached compass. If the camera does not possess a compass, take the bearing of some prominent object and note this with the record of the exposure. The exposure at every station should be made in succession from right to left or left to right, and should be so arranged that the successive views will overlap each other about one-half an inch on the ground glass. This overlap will assist in recognizing the different views and help in orienting the negatives in case bearings are lost or confused. The record taken at each station should give the view number, bearing of the optical axis of each view or a bearing of some prominent object in the view, the displacement of the horizon, if the lens is not at its normal position on the front board, and the height of the horizon above the surface of the ground at the station. If there is no previous triangulation the stations can be located by intersection of bearings taken by a prismatic compass and the distance between two of them measured to serve as a base for plotting. For very rapid reconnoissances a hand camera provided with a level and roll holder can be used to great advantage, the bearings being taken by prismatic compass and distances, if mounted on horseback, by time, or if on a bicycle by the odometer. Special care must be taken with the record of exposures and when the film is

unrolled and cut the different exposures must be kept separate in order to prevent confusion.

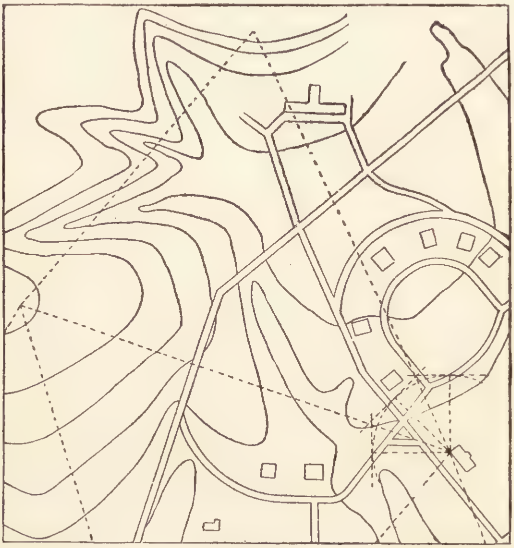


FIG. 23.

Fig. 23 shows a part of a photo-topographical map of Fort Riley, Kans., showing triangulation points and the views at one station reduced from $\frac{1}{2880}$ to $\frac{1}{10000}$.

Preparation of Prints for Plotting Record.

Preparatory to plotting, the prints should have their horizons and middle verticals drawn on them, the corresponding points in different views numbered, the horizontal and vertical distances measured, then the azimuths and elevations computed. The elevation or depression of an object in feet above the horizon is found by measuring the distance on the map in feet from the station and multiplying this by the tangent of

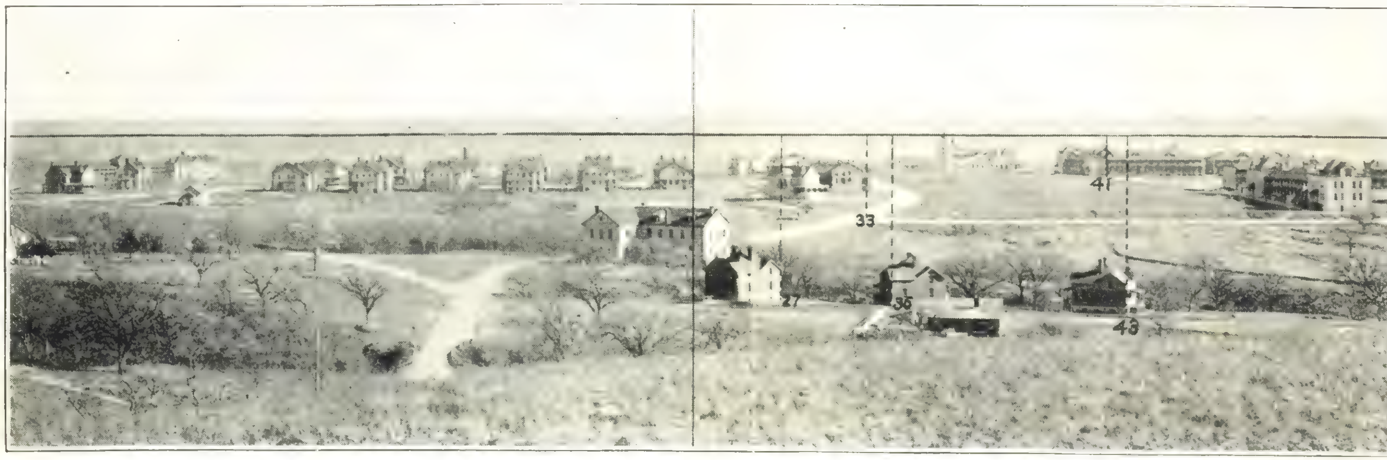


FIG. 24.

the angle of elevation. Fig. 24 shows a print prepared for plotting and the following is a good form of record from which plotting can be performed quite rapidly:

Station B, View No. 2.—Bearing of optical axis, 96° 30′; height of horizon above ground, 5 feet; elevation of Station B, 1,400 feet; elevation of horizon, 1,405 feet.

Point.	Azimuth.	Difference of level.	Altitude of point.
No. 27	R. 2° 56′	—86	1,319
No. 33	R. 5° 40′	—67	1,338
No. 36	R. 6° 31′	—91	1,314
No. 41	R. 13° 7′	—51	1,354
No. 43	R. 13° 56′	—97	1,308

These records were obtained from the original of fig. 24.

Plotting. The bearing of the optical axis of each view is first plotted at the station, then the azimuths, right and left, when the intersection of the lines through the same points on different views will give the location of the point on the plot. If the bearing of the optical axis of the view is not known but the bearing of some point in the view has been observed, the azimuth of the optical axis should be first calculated or constructed, the bearing of the given point plotted and the azimuth of the optical axis then drawn on the proper side, when the optical axis will be located on the plot and will serve as a base from which the various azimuths can be drawn. In case there is an overlap of views, the optical axis of one can be plotted, if the bearing of the optical axis of the other and the bearing of a point situated in both views are known, by first plotting the azimuth of the common point from the view containing the known bearing, then calculate from the other view the azimuth of its optical axis with respect to the common point, and lay this line down on

the paper in the proper direction from the line fixing the azimuth of the common point.

Plotting without Calculation. The several azimuths may be plotted directly without calculation by describing around the station the arc of a circle whose radius is equal to the focal length of the lens. Then draw a radius whose bearing is that of the optical axis of the view, and at its extremity draw a tangent to the circle. This tangent will represent the horizon of the picture and the horizontal distances measured on the view can

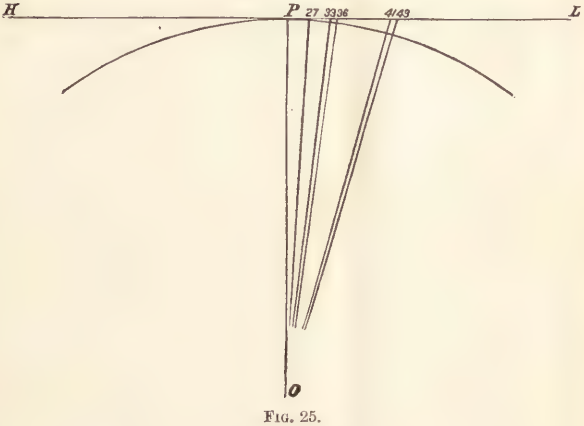


Fig. 25.

be laid off directly on this line as in fig. 25, where the azimuths of the points given in fig. 24 are constructed. The height of an object can be found by a simple proportion, provided its actual distance from the station is known: Measure the height of the object on the view and the length of its azimuth line from the center of the circle above described to the tangent, then the height on the view is to the length of the azimuth line as the real height is to the actual distance. After all the points have been located and the elevation noted the contours can then be drawn in the ordinary way.

The photographs will prove of great assistance in giving the apparent forms to the surface of the ground, and with a little training the eye can readily interpret the perspective of the picture and contours plotted with as much ease in the office as in the field itself.

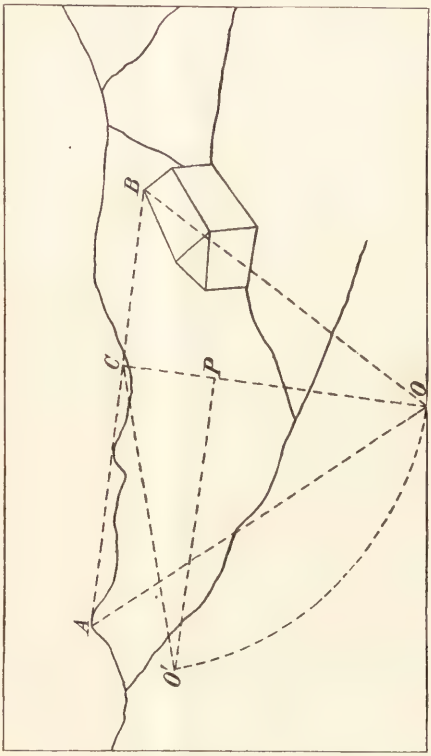


FIG. 26.

Solution of General Case with Camera in any Position. The horizontal position of the camera as before described simplifies the calculation or plotting of angles between objects in the view. The following is a method of

obtaining the angle between any two points in the view in the general case, when the camera is not level: Suppose that fig. 26 represents a view taken with an inclined position of the camera, and it is desired to measure the angle between points A and B. This is the angle that would be measured by a sextant and is in the plane containing the two points A and B and the eye of the observer. P is the point where the optical axis intersects the plane of the picture. Through P draw the line CO perpendicular to AB, and also the line PO′ perpendicular to OC and equal in length to the focus of the lens. With C as a center and O′C as a radius describe the arc O′O and the point O where it cuts the line OC is the position of the optical center of the lens revolved into the plane of the picture. The angle AOB is the required angle. This angle may be calculated by the following formula:

$$\tan A\,O\,B = \frac{A\,B\,\sqrt{f^2 + (P\,C)^2}}{f^2 + (P\,C)^2 - A\,C \times B\,C},$$

f being the focal length of the lens. In case the perpendicular from P upon AB falls outside of the points A or B the sign of the third term of the denominator is plus instead of minus. If the point is on the line AB and this line is the horizon, the formula will, since PC is zero, reduce to the following:

$$\tan A\,O\,B = \frac{A\,B\,f}{f^2 - A\,C \times C\,B},$$

and if the azimuth of A or B is desired with respect to the optical axis the line A B will then become the horizontal distance and the formula reduce to the form,

$$\tan A = \frac{\text{horizontal distance}}{\text{focal length}}.$$

APPENDIX.

USEFUL TABLES AND FORMULAS.

List of Chemical Elements and their Symbols.

Name.	Symbol.
Aluminium	Al
Antimony (Stibium)	Sb
Argon	A
Arsenic	As
Barium	Ba
Beryllium (Glucinum)	Be
Bismuth	Bi
Boron	Bo
Bromine	Br
Carbon	C
Cadmium	Cd
Caesium	Cs
Calcium	Ca
Cerium	Ce
Chlorine	Cl
Chromium	Cr
Cobalt	Co
Copper	Cu
Didymium	Di
Erbium	E
Fluorine	F
Gallium	Ga
Germanium	Ge
Glucinum	G
Gold	Au
Hydrogen	H
Indium	In
Iodine	I
Iridium	Ir
Iron	Fe
Lanthanium	La
Lead (Plumbum)	Pb
Lithium	Li

Name.	Symbol.
Magnesium	Mg
Manganese	Mn
Mercury	Hg
Molybdenum	Mo
Niobium (Columbium)	Nb
Nickel	Ni
Nitrogen	N
Osmium	Os
Oxygen	O
Palladium	Pd
Phosphorus	P
Platinum	Pt
Potassium (Kalium)	K
Rhodium	Rh
Rubidium	Rb
Ruthenium	Ru
Scandium	Sc
Selenium	Se
Silicon (Silicium)	Si
Silver (Argentum	Ag
Sodium (Natrium)	Na
Strontium	Sr
Sulphur	S
Tantalum	Ta
Tellurium	Te
Thallium	Tl
Thorium	Th
Tin (Stannum)	Sn
Tungsten (Wolfram)	W
Uranium	U
Vanadium	V
Ytterbium	Yt
Yttrium	Y
Zinc	Zn
Zirconium	Zr

The following example will show how to use the formula for conjugate foci of lenses: With a 9-inch equivalent focus it is desired to know the distance of the ground glass from the optical center and size of the image of an object 10 feet in height and 60 feet away from the lens. Reduce the feet to inches and substitute for o and f their values in the equation,

$$\frac{1}{i}=\frac{1}{f}-\frac{1}{o} \text{ and it will reduce to}$$

$$\frac{1}{i}=\frac{1}{9}-\frac{1}{720}=.1098, \text{ and } i=9.1 \text{ inches};$$

size of image is to size of object as distance of image from optical center is to distance of object from optical center; size of image is to 120 inches (10 feet reduced to inches) as 9.1 is to 720; solving the proportion the size of image is found to be 1.58 inches in height.

Table C gives the displacement per second in inches of the image on the ground glass when the object is in motion at the different rates of speed and different distances given in the table, which is calculated for a lens with a 9-inch focal length.

TABLE C.

Miles per hour.	Distance of Object from Lens.		
	50 feet.	100 feet.	150 feet.
1	.277	.133	.087
2	.535	.266	.174
3	.803	.399	.261
4	1.071	.532	.348
5	1.338	.666	.435
6	1.605	.799	.522
7	1.873	.932	.609
8	2.131	1.065	.696
9	2.409	1.199	.784
10	2.676	1.332	.871
20	5.353	2.664	1.742
30	8.030	3.996	2.613
40	10.707	5.329	3.484
50	13.384	6.661	4.356
60	16.050	7.993	5.227
70	18.737	9.326	6.098
80	21.314	10.658	6.969
90	24.091	11.991	7.841
100	26.768	13.323	8.712

TABLE D.

Focal length in inches.	Factor.		
	50 feet.	100 feet.	150 feet.
5	0.55	0.55	0.55
6	0.65	0.65	0.66
7	0.72	0.76	0 77
8	0.85	0.88	0.89
9	1.00	1.00	1.00
10	1.16	1.10	1.11
11	1.21	1.20	1.24
12	1.31	1.32	1.32

Table D gives the various factors to apply to Table C for lenses from 5 to 12 inches in focal length, and its use is best explained by an example: It is desired to find out the displacement of the image in feet per second on the ground glass of a camera with a 7-inch focus lens, the object being 150 feet away and moving 15 miles an hour. In Table C look under 150 feet and opposite 5 and 10 miles per hour the quantities .435 and .871 will be found; add these, and we will have 1.306 inches per second for the rate of motion with a 9-inch lens. In Table D under 150 and opposite 7-inch focus we find the factor .77. Multiply 1.306 by .77 and this will give 1.005 inches per second as the rate of motion of the image of an object moving 15 miles an hour 150 feet away from a 7-inch lens.

The rate of motion of the image on the ground glass in inches per second of any object made by a lens is given by the expression, $17.6\,\frac{v\,f}{o-f}$ in which v is the velocity in miles per hour, o the distance of the object from the camera in inches, and f the focal length of the lens in inches.

Tables C and D will show whether or not a shutter will work fast enough to give a sharp picture of an object in motion. In a photograph the normal eye can not distinguish a blurring of outlines if the image has moved less than $\frac{8}{1000}$ of an inch on the negative during the exposure. It is only necessary to multiply the tabular value by the lengths of exposure, and if this is less than $\frac{8}{1000}$ of an inch the resulting picture will be sharp, and vice versa will indicate the proper exposure to get a sharp picture.

Table of universal foci for different stops or the distance in feet from the camera to the point beyond which all objects are in focus on the ground glass.

Equivalent focus, inches.	$\frac{f}{8}$	$\frac{f}{11}$	$\frac{f}{16}$	$\frac{f}{32}$	$\frac{f}{64}$
4	20.9	15.2	10.4	5.1	3.2
5	32.6	23.6	16.3	8.3	4.1
6	47.4	34.5	23.6	11.8	7.1
7	61.8	46.3	32.0	16.0	8.0
8	83.6	60.9	41.7	20.9	10.4
9	106.6	77.6	53.2	26.6	13.3
10	131.3	95.6	65.6	32.8	16.4
11	158.4	107.9	79.1	39.5	19.7
12	188.9	136.1	94.5	47.3	23.6

METRIC LENGTHS.

Denominations and values.		Equivalents in use.	
Myriameter	10,000 meters.	6.2137	miles.
Kilometer	1,000 meters.	.62137	mile, or 3,280 feet 10 inches.
Hectometer	100 meters.	328.	feet and 1 inch.
Dekameter	10 meters.	393.7	inches.
Meter	1 meter.	39.37	inches.
Decimeter	1-10th of a meter.	3.937	inches.
Centimeter	1-100th of a meter.	.3937	inch.
Millimeter	1-1000th of a meter.	.0394	inch.

METRIC FLUID MEASURE.

1 cubic centimeter	=	17 minims.	
2 cubic centimeters	=	34 minims.	
3 cubic centimeters	=	51 minims.	
4 cubic centimeters	=	68 minims	or 1 dram 8 minims.
5 cubic centimeters	=	85 minims	or 1 dram 25 minims.
6 cubic centimeters	=	101 minims	or 1 dram 41 minims.
7 cubic centimeters	=	118 minims	or 1 dram 58 minims.
8 cubic centimeters	=	135 minims	or 2 drams 15 minims.
9 cubic centimeters	=	152 minims	or 2 drams 32 minims.
10 cubic centimeters	=	169 minims	or 2 drams 49 minims.
20 cubic centimeters	=	338 minims	or 5 drams 38 minims.
30 cubic centimeters	=	507 minims	or 1 ounce 0 dram 27 minims.
40 cubic centimeters	=	676 minims	or 1 ounce 3 drams 16 minims.
50 cubic centimeters	=	845 minims	or 1 ounce 6 drams 5 minims.
60 cubic centimeters	=	1014 minims	or 2 ounces 0 dram 54 minims.
70 cubic centimeters	=	1183 minims	or 2 ounces 3 drams 43 minims.
80 cubic centimeters	=	1352 minims	or 2 ounces 6 drams 32 minims.
90 cubic centimeters	=	1521 minims	or 3 ounces 1 dram 21 minims.
100 cubic centimeters	=	1690 minims	or 3 ounces 4 drams 10 minims.
1000 cubic centimeters	=	1 liter = 34 fluid ounces nearly, or $2\frac{1}{8}$ pints.	

METRIC WEIGHTS.

1 gram	=	$15\frac{2}{5}$ grains.	
2 grams	=	$30\frac{4}{5}$ grains.	
3 grams	=	$46\frac{1}{5}$ grains.	
4 grams	=	$61\frac{4}{5}$ grains	or 1 dram $1\frac{4}{5}$ grains.
5 grams	=	$77\frac{1}{5}$ grains	or 1 dram $17\frac{1}{5}$ grains.
6 grams	=	$92\frac{3}{5}$ grains	or 1 dram $32\frac{3}{5}$ grains.
7 grams	=	108 grains	or 1 dram 48 grains.
8 grams	=	$123\frac{2}{5}$ grains	or 2 drams $3\frac{2}{5}$ grains.
9 grams	=	$138\frac{4}{5}$ grains	or 2 drams $18\frac{4}{5}$ grains.
10 grams	=	$154\frac{2}{5}$ grains	or 2 drams $34\frac{2}{5}$ grains.
11 grams	=	$169\frac{4}{5}$ grains	or 2 drams $49\frac{4}{5}$ grains.
12 grams	=	$185\frac{1}{5}$ grains	or 3 drams $5\frac{1}{5}$ grains.
13 grams	=	$200\frac{3}{5}$ grains	or 3 drams $20\frac{3}{5}$ grains.
14 grams	=	216 grains	or 3 drams 36 grains.
15 grams	=	$231\frac{2}{5}$ grains	or 3 drams $51\frac{2}{5}$ grains.
16 grams	=	247 grains	or 4 drams 7 grains.
17 grams	=	$262\frac{2}{5}$ grains	or 4 drams $22\frac{2}{5}$ grains.
18 grams	=	$277\frac{4}{5}$ grains	or 4 drams $37\frac{4}{5}$ grains.
19 grams	=	$293\frac{1}{5}$ grains	or 4 drams $53\frac{1}{5}$ grains.
20 grams	=	$308\frac{3}{5}$ grains	or 5 drams $8\frac{3}{5}$ grains.
30 grams	=	463 grains	or 7 drams 43 grains.
40 grams	=	$617\frac{1}{5}$ grains	or 10 drams $17\frac{1}{5}$ grains.
50 grams	=	$771\frac{3}{5}$ grains	or 12 drams $51\frac{3}{5}$ grains.
60 grams	=	926 grains	or 15 drams 26 grains.
70 grams	=	$1080\frac{1}{5}$ grains	or 18 drams $0\frac{1}{5}$ grain.
80 grams	=	$1234\frac{3}{5}$ grains	or 20 drams $34\frac{3}{5}$ grains
90 grams	=	1389 grains	or 23 drams 9 grains.
100 grams	=	$1543\frac{1}{5}$ grains	or 25 drams $43\frac{1}{5}$ grains.
1000 grams	=	1 kilogram = 32 ounces, 1 dram, $12\frac{2}{5}$ grains.	

Table showing the comparisons of the readings of thermometers.

[Celsius, or Centigrade (C). Réaumur (R). Fahrenheit (F).]

C.	R.	F.
−30	−24.0	−22.0
−25	−20.0	−13.0
−20	−16.0	− 4.0
−15	−12.0	+ 5.0
−10	− 8.0	14.0
− 5	− 4.0	23.0
− 4	− 3.2	24.8
− 3	− 2.4	26.6
− 2	− 1.6	28.4
− 1	− 0.8	30.2
Freezing point of water.		
0	0.0	32.0
1	0.8	33.8
2	1.6	35.6
3	2.4	37.4
4	3.2	39.2
5	4.0	41.0
6	4.8	42.8
7	5.6	44.6
8	6.4	46.4
9	7.2	48.2
10	8.0	50.0
11	8.8	51.8
12	9.6	53.6
13	10.4	55.4
14	11.2	57.2
15	12.0	59.0
16	12.8	60.8
17	13.6	62.6
18	14.4	64.4
19	15.2	66.2
20	16.0	68.0
21	16.8	69.8
22	17.6	71.6

C.	R.	F.
23	18.4	73.4
24	19.2	75.2
25	20.0	77.0
26	20.8	78.8
27	21.6	80.6
28	22.4	82.4
29	23.2	84.2
30	24.0	86.0
31	24.8	87.8
32	25.6	89.6
33	26.4	91.4
34	27.2	93.2
35	28.0	95.0
36	28.8	96.8
37	29.6	98.6
38	30.4	100.4
39	31.2	102.2
40	32.0	104.0
41	32.8	105.8
42	33.6	107.6
43	34.4	109.4
44	35.2	111.2
45	36.0	113.0
50	40.0	122.0
55	44.0	131.0
60	48.0	140.0
65	52.0	149.0
70	56.0	158.0
75	60.0	167.0
80	64.0	176.0
85	68.0	185.0
90	72.0	194.0
95	76.0	203.0
100	80.0	212.0
Boiling point of water.		

USUAL SIZES OF FRENCH, GERMAN, AND ITALIAN DRY PLATES.

French and German.		Italian.	
Centimeters.	*Inches.*	*Centimeters.*	*Inches.*
6½ x 9	2.5 x 3.6	9 x 12	3.6 x 4.7
9 x 12	3.6 x 4.7	12 x 16	4.7 x 6.3
12 x 15	4.7 x 5.9	12 x 18	4.7 x 7.2
13 x 18	5.1 x 7.0	13 x 18	5.1 x 7.0
12 x 20	4.7 x 7.8	12 x 20	4.7 x 7.8
15 x 21	5.9 x 8.2	18 x 24	7.0 x 9.4
15 x 22	5.9 x 8.6	21 x 27	8.2 x 10.6
18 x 24	7.2 x 9.4	24 x 30	9.4 x 11.8
21 x 27	8.2 x 10.6	27 x 33	10.6 x 12.9
24 x 30	9.4 x 11.8	30 x 36	11.8 x 14.1
27 x 33	10.6 x 12.9	40 x 50	15.7 x 19.6
27 x 35	10.6 x 13.7	50 x 60	19.6 x 23.6
30 x 40	11.8 x 15.7		
40 x 50	15.7 x 19.6		
50 x 60	19.6 x 23.6		

SIZES OF GLASS, MOUNTS, PAPER, ETC.

	Inches.
Petite cards	1⅝ x 3⅛
One-ninth plate	2 x 2½
One-sixth plate	2¾ x 3¼
One-fourth plate	3¼ x 4¼
Half plate	4¼ x 5½ and 4¼ x 6½
Half plate (English)	4¾ x 6½
Whole plate (4-4)	6½ x 8½
Extra 4-4	8 x 10

Other sizes are expressed by inches.

SIZES OF MOUNTS.

Stereoscopic ---------- 3½ x 7, 4 x 7, 4¼ x 7, 4½ x 7, 5 x 8

Victoria	3¼ x 5	Minette	1½ x 2⅜
Imperial	7⅞ x 9⅞	Card	2½ x 4⅛
Boudoir	5¼ x 8½	Cabinet	4¼ x 6½
Panel	4 x 8¼	Promenade	4⅛ x 7⅛

SIZES OF ALBUMEN PAPER.

18 x 22¾, 20½ x 24½, 22 x 36, 26 x 40, 27 x 42.

Size of blotting paper ---------- 19 x 24

"PER CENT" SOLUTIONS.

In each fluid ounce of a

1 per cent solution there are	4.55 grains.
2 per cent solution there are	9.10 grains.
3 per cent solution there are	13.65 grains.
4 per cent solution there are	18.20 grains.
5 per cent solution there are	22.75 grains.
6 per cent solution there are	27.30 grains.
7 per cent solution there are	31.85 grains.
8 per cent solution there are	36.40 grains.
9 per cent solution there are	40.95 grains.
10 per cent solution there are	45.50 grains.
11 per cent solution there are	50.05 grains.
12 per cent solution there are	54.60 grains.
13 per cent solution there are	59.15 grains.
14 per cent solution there are	63.70 grains.
15 per cent solution there are	68.25 grains.
16 per cent solution there are	72.80 grains.
17 per cent solution there are	77.35 grains.
18 per cent solution there are	81.90 grains.
19 per cent solution there are	86.45 grains.
20 per cent solution there are	91.00 grains.
25 per cent solution there are	113.75 grains.
30 per cent solution there are	136.50 grains.
35 per cent solution there are	159.25 grains.
40 per cent solution there are	182.00 grains.
45 per cent solution there are	204.75 grains.
50 per cent solution there are	227.50 grains.
60 per cent solution there are	273.00 grains.
70 per cent solution there are	318.50 grains.
80 per cent solution there are	364.00 grains.
90 per cent solution there are	409.50 grains.
100 per cent solution there are	555.00 grains.

A GOOD NONHALATION BACKING.

Caramel	1 ounce.
Burnt sienna	1 ounce.
Methylated spirits	1 ounce.
Water	1 ounce.

(Boil well before applying to back of plate.)

A FEW REMEDIES AGAINST BLISTERING OF ALBUMEN PAPER.

Do not dry the paper by excessive heat.

Avoid acidity in solutions.

Moisten the print before washing with a sponge saturated in alcohol.

Immerse the print, before fixing, in a weak alum bath.

Add a trace of aqua ammonia to the fixing bath.

Add one-tenth part of alcohol to the ordinary toning bath.

MAT BLACK VARNISH.

A tolerably strong solution of sandarac in alcohol, mixed with fine lampblack, dries without gloss, becomes hard without being brittle, and may be applied with a fine brush upon almost any substance.

INVISIBLE INK.

Chloride of cobalt	50 gr.
Distilled water	1 fluid ounce.
Glycerin	10 minims.

Dissolve the chloride of cobalt in the distilled water, and add the glycerin.

Writing executed with this ink is invisible on paper, but on warming this writing turns blue. On exposure to damp air it becomes invisible again.

SOLUTION FOR MAKING PAPER ADHERE TO METAL.

Tragacanth	30 gm.
Gum arabic	120 gm.
Water	500 c. c.

NEGAVIVE VARNISH.

Tough, hard, and durable.

Shellac	1¼ ounces.
Mastic	¼ ounce.
Oil of turpentine	¼ ounce.
Sandarac	2¼ ounces.
Venice turpentine	¼ ounce.
Camphor	20 gr.
Alcohol	20 fluid ounces.

GROUND-GLASS VARNISH.

Sandarac	90 gr.
Mastic	20 gr.
Ether	2 fluid ounces.
Benzol	½ to 1½ fluid ounces.

The proportion of the benzol added determines the nature of the mat obtained.

TO REMOVE YELLOW STAINS FROM BROMIDE PRINTS.

Soak for one or two hours in

Acetic acid	2 ounces.
Saturated oxalate of potassium solution	4 ounces.

TO REMOVE PYRO STAINS FROM FINGERS.

Wash with a 10 per cent solution of oxalic acid, or sulphuric acid, diluted with water, 1:20.

To soften india-rubber articles, such as tubes and bulbs, that have become hard through age, plunge them into a bath of water two parts and ammonia one part for a time varying between a few minutes to an hour, depending upon the degree of hardness. If there are any holes or cracks they may then be filled with a cement prepared by dissolving pure rubber in benzol.

To unscrew a lens from its tube, do not use pinchers or a vice, but take a turn around the lens with a piece of tape, holding the standing part of the tape firmly in one hand and pulling the running end with the other in the direction of unscrewing. If this is not successful apply moderate heat from an alcohol flame to the threads of the screw and turn the lens and tube in opposite directions.

If the crown and flint element of a lens have become separated or if the balsam holding them together has become discolored, heat the lens very gradually and its two parts will separate. Clean the glasses with a piece of chamois skin and alcohol. Then put a drop of Canada balsam between the glasses and set aside for a couple of days where the dust can not fall on the glasses till the balsam hardens thoroughly.

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